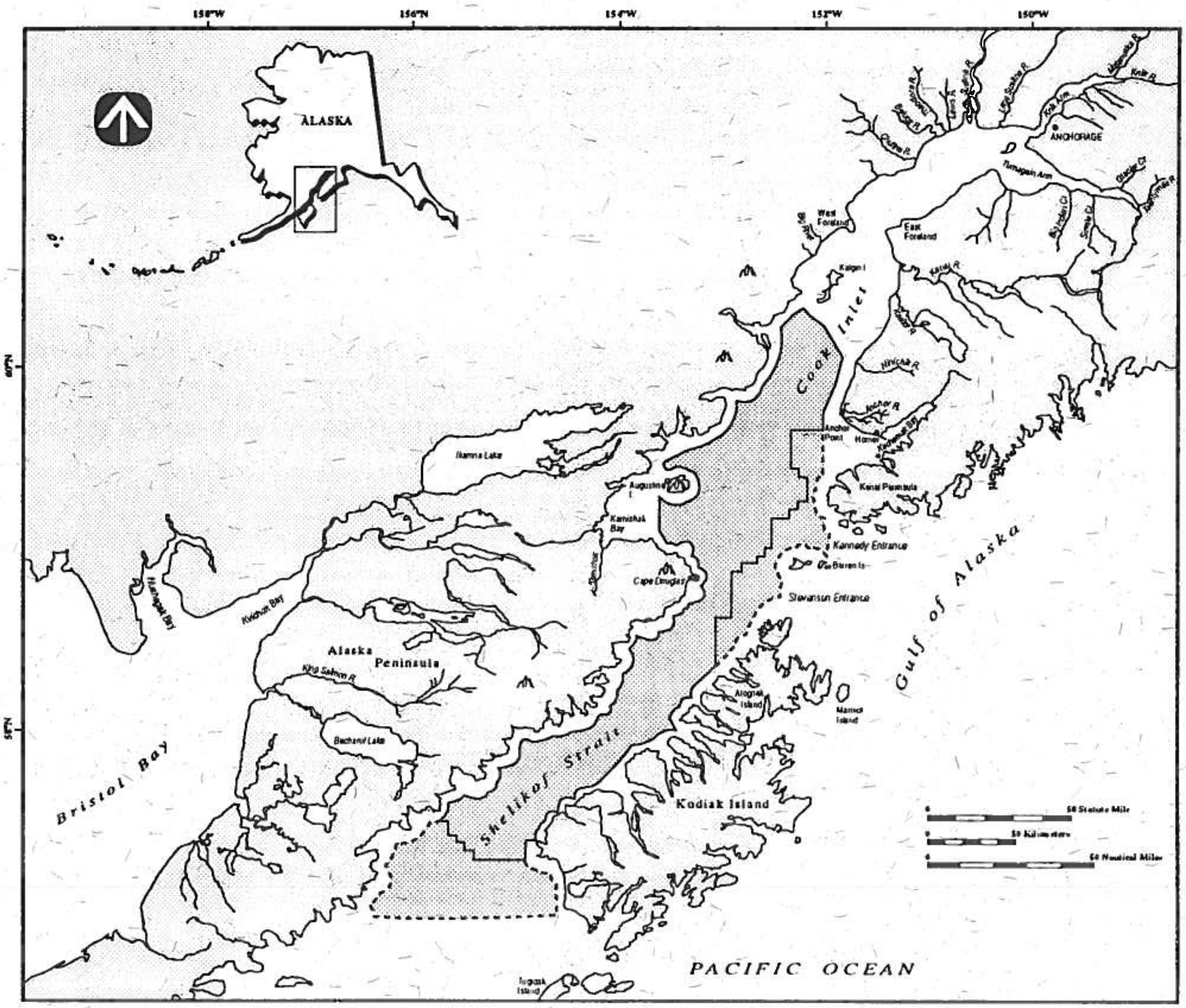
FINAL REPORT
TC 6516-15

Ocean Discharge Criteria Evaluation for Cook Inlet/Shelikof Strait Oil and Gas Lease Sale 149



OCTOBER 13, 1993

Prepared For:

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION X
SEATTLE WASHINGTON

TETRA TECH

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SEATTLE WASHINGTON

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ACKNOWLEDGEMENTS

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The authors of this report were Ms. Kimberle Stark, Dr. Ellis, and Mr. Tad Deshler. Dr. Ellis performed technical review, Ms. Kim Tapia provided illustrations, and word processing was conducted by Ms. Lisa Fosse and Ms. Clarissa Hutchinson.

LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Alaska Administrative Code
ac	Acre
ACC	Alaskan Coastal Current
ACMP	Alaska Coastal Management Program
ACW	Alaska Coastal Water
AMSA	Area Meriting Special Attention
bbl/h	Barrels per hour
BCF	Bioconcentration Factors
CDU	Conical Drilling Unit
CFR	Code of Federal Regulations
CIDS	Concrete Island Drilling System
CMF	Consumption of Marine Fish
CMP	Coastal Management Plan
CWA	Clean Water Act
CZMP	Coastal Zone Management Program
DOI	United States Department of the Interior
DMR	Discharge Monitoring Report
EC_{50}	Effective Concentration Causing a Non-Lethal Effect to 50 Percent of Test Organisms
EOP	End of Pipe
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
FDA	Food and Drug Administration
FEIS	Final Environmental Impact Statement
FR	Federal Register
ha	Hectares
HQ	Hazard Quotient
KCl	Potassium chloride

LC_{50}	Lethal Concentration to 50 Percent of Test Organisms
LOEL	Lowest Observed Effects Level
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MZ	Mixing Zone
NMFS	National Marine Fisheries Service
nmi	Nautical miles
NPDES	National Pollutant Discharge Elimination System
OCS	Outer Continental Shelf
ODCE	Ocean Discharge Criteria Evaluation
OOC	Offshore Operators Committee
PAH	Polycyclic Aromatic Hydrocarbons
PRESTO	Probabilistic Resource Estimate - OCS
ppm	Parts per million
SSDC	Single Steel Drilling Caisson
TVD	True Vertical Depth
v/v	Volume to Volume Ratio

1.0 INTRODUCTION

1.1 PURPOSE OF EVALUATION

The U.S. Environmental Protection Agency (EPA) intends to issue a National Pollutant Discharge Elimination System (NPDES) general permit for effluent discharges associated with oil and gas exploration in Alaskan state waters located in the Cook Inlet and Shelikof Strait areas incorporated within Federal Lease Sale 149 (Figure 1-1). Section 403(c) of the Clean Water Act (CWA) requires that NPDES permits for such ocean discharges be issued in compliance with U.S. EPA's Ocean Discharge Criteria for preventing unreasonable degradation of ocean waters. The purpose of this Ocean Discharge Criteria Evaluation (ODCE) report is to identify the salient information and concerns relative to the Ocean Discharge Criteria and exploratory petroleum drilling in these waters.

U.S. EPA's Ocean Discharge Criteria (40 CFR Part 125, Subpart M) set forth specific determinations of unreasonable degradation that must be made prior to permit issuance. "Unreasonable degradation of the marine environment" is defined (40 CFR 125.121[e]) as follows:

"(1) Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities,

(2) Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms, or

(3) Loss of aesthetic, recreational, scientific, or economic values, which are unreasonable in relation to the benefit derived from the discharge."

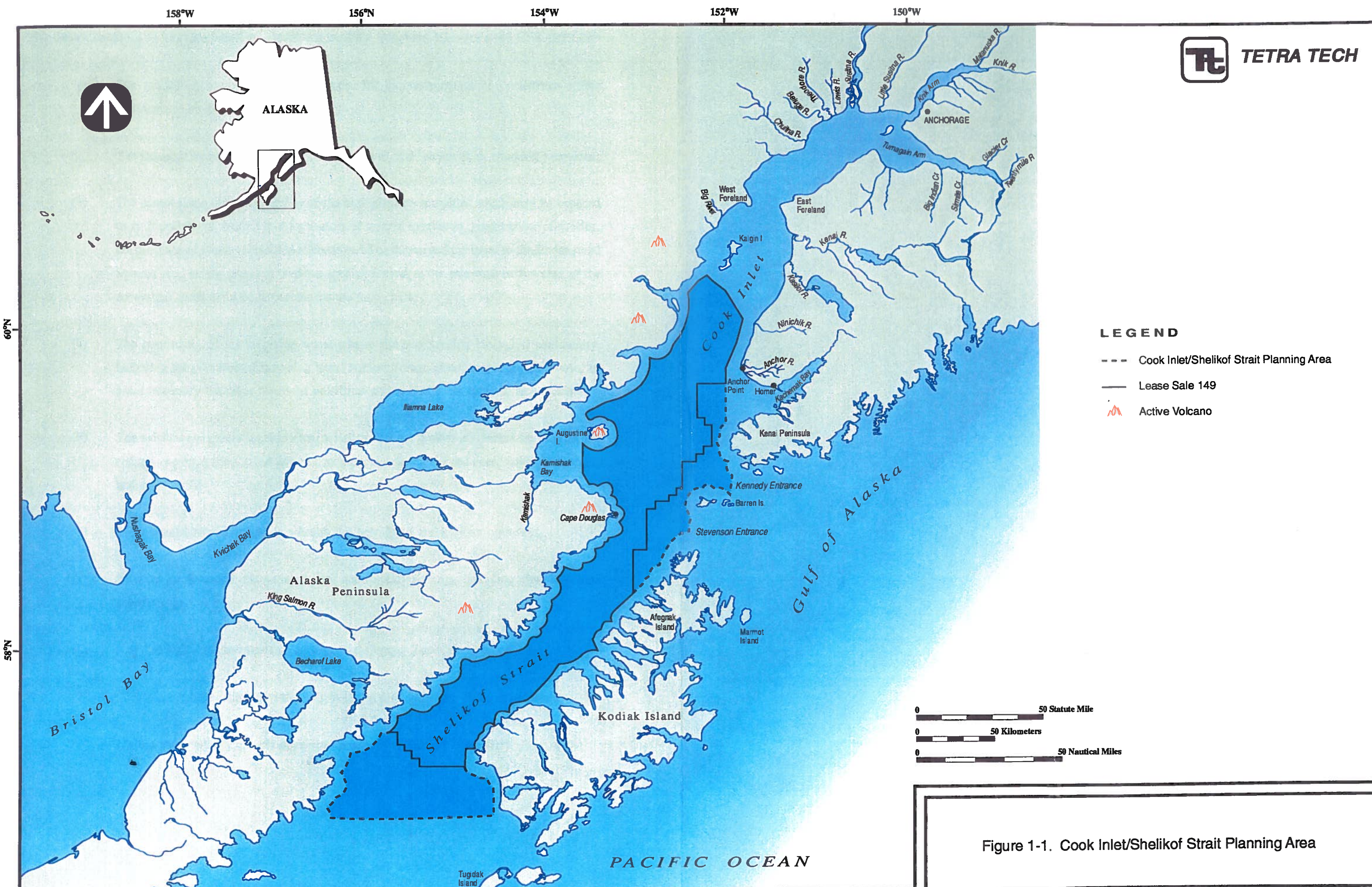


Figure 1-1. Cook Inlet/Shelikof Strait Planning Area

This determination is to be made based on consideration of the following 10 criteria (40 CFR 125.122):

"(1) The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged;

(2) The potential transport of such pollutants by biological, physical, or chemical processes;

(3) The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain;

(4) The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism;

(5) The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs;

(6) The potential impacts on human health through direct and indirect pathways;

(7) Existing or potential recreational and commercial fishing, including finfishing and shellfishing;

(8) Any applicable requirements of an approved Coastal Zone Management Plan;

(9) Such other factors relating to the effects of the discharge as may be appropriate;

(10) Marine water quality criteria developed pursuant to Section 304(a)(l)."

If the Regional Administrator determines that the discharge will not cause unreasonable degradation to the marine environment, an NPDES permit may be issued. A specific NPDES permit may be issued for distinct locations within the Lease Sale boundaries necessitating special consideration due to sensitivity or biological concern. If the Regional Administrator determines that the discharge will cause unreasonable degradation to the marine environment, an NPDES permit may not be issued.

If the Regional Administrator has insufficient information to determine, prior to permit issuance, that there will be no unreasonable degradation to the marine environment, an NPDES permit will not be issued unless the Regional Administrator, on the basis of the best available information, determines that: 1) such discharge will not cause irreparable harm to the marine environment during the period in which monitoring will take place, 2) there are no reasonable alternatives to the onsite disposal of these materials, and 3) the discharge will be in compliance with certain specified permit conditions (40 CFR 125.122). "Irreparable harm" is defined as "significant undesirable effects occurring after the date of permit issuance which will not be reversed after cessation or modification of the discharge" (40 CFR 125.121[a]).

1.2 SCOPE OF EVALUATION

This document utilizes information provided in the previous Sale 60 preliminary ODCE for the Cook Inlet and Shelikof Strait (U.S. EPA 1983) and previous Sale 88 preliminary ODCE for the Cook Inlet (U.S. EPA 1984). Where appropriate, the reader will be referred to these publications for more detailed information concerning certain topics. The information presented here is a synthesis of these documents and current data, along with the inclusion of discharge modeling results and findings recently published in the scientific literature.

1.2.1 Cook Inlet Shelikof Strait Planning Area

This document evaluates the impacts of waste discharges as provided for by the general NPDES permit proposed for offshore oil and gas exploration in Cook Inlet and Shelikof Strait under Federal OCS Lease Sale 149 pursuant to Section 403(c) of the Clean Water Act.

Federal Outer Continental Shelf Oil and Gas Lease Sale 149, hereafter referred to as the Cook Inlet/Shelikof Strait Planning Area, includes approximately 1.5 million hectares(ha)[3.7 million ac] of the

Cook Inlet/Shelikof Strait Planning Area (Figure 1-1). The sale area extends from Cape Ikolik at approximately 57°15' N. latitude and 154°50'W. longitude north along the western side of Kodiak Island up to approximately 60°20' N.latitude and 152°15' W. longitude in Cook Inlet, then continues south around Augustine Island and south through Shelikof Strait to the point of origin.

Depths in the Lease Sale area range from approximately 13.5 m (44 ft) in the north end of the sale area near Kalgin Island in Cook Inlet to approximately 290 m (951 ft) in the south end of the sale area in Shelikof Strait. In lower Cook Inlet, most water depths within the sale area range from 75 to 90 m (246 to 295 ft). In Shelikof Strait, most water depths within the sale area range from 150 to 180 m (492 to 590 ft).

1.3 OVERVIEW OF REPORT

The evaluation focuses on sources, fate, and potential effects of exploratory drilling rig discharges on various groups of aquatic life. The types and projected quantities of discharges are detailed in Section 2.0. Anticipated amounts or volumes of wastes, approximate chemical composition, and chemical concentrations are also given. Following discharge, the fate of the wastes is examined in Section 3.0, which covers dilution, dispersion, and persistence of discharged constituents in relation to influential receiving water properties, including water depth, ice coverage, currents, wind, and waves. Section 3.0 also provides estimates of the vertical and horizontal coverage and deposition of the discharges. This information is needed to assess aquatic toxicity and food chain accumulation questions, and the probability of burying benthic infaunal invertebrates or otherwise modifying their habitat chemically or physically (e.g., via grain size changes). Before discussing potential biological and ecological effects, an overview of aquatic communities and important species is presented in Section 4.0. The means by which drilling mud discharges could impact marine life and concentrations at which effects have been documented are presented in Section 5.0. Section 6.0 serves as the "biological assessment" of endangered and threatened species required by the Endangered Species Act. Particularly important uses and plans for the Cook Inlet and Shelikof Strait sale area, including commercial, recreational and subsistence harvests, special aquatic sites, and coastal zone management plans, are discussed in Sections 7.0 and 8.0. Section 9.0 discusses the compliance of expected exploratory drilling discharges with U.S. EPA water quality criteria. Section 10.0 summarizes the findings of this report and Section 11.0 presents recommendations for monitoring marine life that could be affected by exploratory drilling in the proposed Lease Sale area.

2.0 COMPOSITION AND QUANTITIES OF MATERIALS DISCHARGED

The determination of "unreasonable degradation" of the marine environment is to be based on consideration of the ten criteria listed in section 1.0. The following section provides information pertinent for the consideration of the *Ocean discharge* criterion listed below:

- **Criteria #1:** The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged.

2.1 TYPES OF DISCHARGES FROM EXPLORATORY DRILLING

Exploratory oil and gas drilling generates a wide range of waste materials related to the drilling process, equipment maintenance, and personnel housing. These materials are commonly discharged directly from the rig into the receiving water. Discharges of primary concern to this evaluation are drilling fluids, also called drilling muds, and cuttings. Drilling muds are the fluids used to lubricate the drill bit and stem and to remove waste rock particles ("cuttings") that are brought up from the hole during the drilling operation.

During a typical drilling operation, the drilling fluids are recirculated. The major components of the mud are mixed on board. These components are fed into mud pits or bins that are then pumped down the central shaft of the drill pipe to the drill bit. At this point, they pass through holes in the bit, pick up rock chips (cuttings) loosened by the bit and return to the surface between the drill pipe and the bore hole. At the surface, the mud and cuttings are passed through a shale shaker, where the cuttings and mud are separated. The cuttings are either saved for analysis or are washed overboard. The mud is returned to the mud pits for recycling. The solids-control equipment is unable to separate fine clay and colloidal particles that accumulate in the mud system during drilling. Therefore, as drilling proceeds, these components accumulate and eventually the mud becomes too viscous for further use. When this happens, a portion of the mud is discharged, and water and mud additives are added to the remaining drilling mud to bring concentrations back to proper levels (Menzie 1982). According to U.S. EPA (1985, p. 2-54), discharges occur at time intervals ranging from less than 1 h/day to 24 h/day, depending on the type of operations and the characteristics of the specific well.

Muds and cuttings are of prime concern due to their volume and composition, and are discussed in Sections 2.2 and 2.3. Other discharges of lesser significance are discussed in Section 2.4.

2.1.1 Types of Drilling Platforms

The number and type of exploratory wells that may be drilled in the Cook Inlet/Shelikof Strait Planning Area are estimated in the preliminary draft appendix of the Environmental Impact Statement (EIS) for Lease Sale 149 (Jones and Stokes 1993). Three resource scenarios (low, base, and high) for oil and gas exploration and development within the Lease Sale area were generated by the Minerals Management Service computer model PRESTO (Probabilistic Resource Estimate-OCS). A total of 3 exploratory wells are predicted for the Low Resource scenario; 6 exploratory wells and 2 delineation wells are predicted for both the Base Resource and High Resource scenarios. Since most of the unleased blocks in the planning area lie in waters deeper than 20 m (66 ft), it is estimated that bottom-founded mobile drilling units, such as the Concrete Island Drilling System (CIDS) or the Single Steel Drilling Caisson (SSDC), and floating vessels, such as ice-strengthened drillships or the Conical Drilling Unit (CDU), would be used to drill the exploration wells. Present day bottom-founded mobile units are designed to operate year-round in waters as deep as about 25 m (82 ft). With icebreaker assistance, the floating units are capable of operating in limited sea-ice conditions (U.S. DOI 1990, p. II-3).

2.1.2 Pollutant Sources from Drilling Rigs

Exploratory oil and gas well drilling activities produce a wide range of waste materials that are discharged into receiving waters. The major discharges are drilling muds (fluids) and cuttings. Other discharges may include sanitary and domestic wastes, desalination unit wastes, boiler blowdown, test fluids, deck drainage, blowout preventer fluids, uncontaminated ballast and bilge water, excess cement slurry, compounds used for equipment and drilling maintenance activities (e.g., waterflooding discharges, produced water, completion fluids, workover fluids, and well treatment fluids), non-contact cooling water, fire control system test water, produced solids, and muds, cuttings, and cement at the seafloor.

2.2 COMPOSITION OF DRILLING MUDS

2.2.1 General Composition

Drilling muds are complex mixtures of clays, barite, and specialty additives used primarily to remove rock particles from the hole created by the drill bit. The composition of drilling mud can vary over a wide range from one hole to the next, as well as during the course of drilling a single hole.

2.2.1.1 Function. Drilling muds serve several other functions in addition to removing solids. These include cooling and lubricating the drill bit, removing and transporting cuttings from the hole to the surface, and controlling formation pressures. As the hole becomes deeper and encounters different formations, the type of mud may need to be changed or the composition altered.

2.2.1.2 Chemical Composition. The generic water-based mud types that have been evaluated and approved by U.S. EPA during permit development are shown in Table 2-1, along with the primary components of each type of mud and their maximum U.S. EPA-authorized concentrations. Each mud differs in its basic components, and a single mud type can vary substantially in composition. Specialty additives may also be added. Non-generic muds have also been approved for discharge by U.S. EPA. These muds are similar in composition to the generic muds, but certain components (e.g., KCl) exceed the allowable concentration for the corresponding generic mud. U.S. EPA does not intend to continue making a distinction between generic and non-generic muds in future NPDES permits because the concentration of potentially toxic pollutants does not differ appreciably between the two groups (Flint, K., 8 March 1993, personal communication).

2.2.2 Metals

The presence of potentially toxic trace elements in drilling muds and cuttings is of primary concern. Metals including lead, zinc, mercury, arsenic, vanadium and cadmium can be present as impurities in barite; chromium is present in chrome lignosulfonates and chrome-treated lignite (U.S. EPA 1984a, p. 14). According to Jones & Stokes (1990, p. 14), drill pipe dope (which is known to contain 115 percent copper and 7 percent lead), and drill collar dope (which can contain 35 percent zinc, 20 percent lead, and 7 percent copper), may also contribute trace metals to the muds and cuttings discharge.

TABLE 2-1. APPROVED DRILLING MUD TYPES FOR COOK INLET/GULF OF ALASKA GENERAL PERMIT

Components	Maximum Authorized Concentration (lb/bbl dry weight)
1. Seawater/Freshwater/Potassium/Polymer Mud	
KCL	50
Starch	12
Cellulose polymer	5
XC polymer	2
Drilled solids	100
Caustic	3
Barite	575
Seawater or freshwater	As needed
2. Seawater/Lignosulfonate Mud	
Bentonite[a]	50
Lignosulfonate, Chrome or Ferrochrome	15
Lignite, Untreated or Chrome-treated	10
Caustic	5
Lime	2
Barite	575
Drilled solids	100
Soda ash/Sodium bicarbonate	2
Cellulose polymer	5
Seawater	As needed
3. Lime Mud	
Lime	20
Bentonite[a]	50
Lignosulfonate, Chrome or Ferrochrome	15
Lignite, Untreated or Chrome-treated	10
Caustic	5
Barite	575
Drilled solids	100
Soda ash/Sodium bicarbonate	2
Seawater or freshwater	As needed
4. Nondispersed Mud	
Bentonite[a]	50
Acrylic polymer	2
Lime	2
Barite	180
Drilled solids	70
Seawater or freshwater	As needed
5. Spud Mud	
Lime	2
Bentonite[a]	50
Caustic	2
Barite	50
Soda ash/Sodium bicarbonate	2
Seawater	As needed
6. Seawater/Freshwater Gel Mud	
Lime	2
Bentonite[a]	50
Caustic	3
Barite	50
Drilled solids	100
Soda ash/Sodium bicarbonate	2
Cellulose polymer	2
Seawater or freshwater	As needed

[a] Attapulgite, sepiolite, or montmorillonite may be substituted for bentonite.
Source: U.S. EPA (1988d). General NPDES Permit No. AKG285000.

2.2.2.1 Trace Metal Concentrations of Drilling Muds. Trace metal concentrations expected in oil and gas exploratory drilling muds are presented in Table 2-2. The metal concentrations at the left of Table 2-2 were determined by CENTEC (1984). The laboratory-produced muds in this study were hot-rolled prior to analysis to simulate chemical changes induced by downhole conditions; however, the muds contained no additives. The concentrations at the right of Table 2-2 represent the median, minimum, and maximum values, respectively, obtained from the U.S. EPA, Region X's drilling mud database (created primarily from end-of-well reports). The variation in metal concentrations has been attributed to the addition of authorized specialty additives, differences in base mud components (i.e., chrome-free lignosulfonate replacing chrome-containing lignosulfonate), incidental contamination from pipe dope, and possibly to differences in laboratory analyses and sample sources (Jones & Stokes 1989a, p. 13).

The average trace metal concentrations in the earth's continental crust provide an estimate of metal concentrations to be expected in drilling cuttings. Comparison of these concentrations with the maximum values reported for generic muds and the maximum values reported during the most recent permitting period of discharge in Alaskan waters provides an assessment of the enrichment above natural metal levels represented by drilling mud discharges. The enrichment values shown in Table 2-3 show that, with the exception of nickel and copper, drilling mud discharge contains concentrations of trace metals higher than that found in the continental crust. Barium shows the greatest enrichment, with mud discharge having levels as much as 1,165 times higher than the average value for the continental crust.

2.2.2.2 Chrome Lignosulfonates. Chrome lignosulfonates may be present in two of the generic muds (Numbers 2 and 3) listed in Table 2-1. According to Jones & Stokes (1989a, p. 13), when chrome lignosulfonates are added to drilling muds, they adsorb to the clay component, and inhibit flocculation and loss of mud viscosity. However, chrome lignosulfonates are readily soluble in water [approximately 500 g/L (4.2 lb/gal)], and the extent to which they may be displaced from drilling muds during use, or by seawater ions after discharge, has not been determined. The discharge of chrome lignosulfonates is of concern because they apparently resist decomposition and persist in the marine environment for long periods of time. Marine sediments are the likely repository for discharged chrome lignosulfonates, although the precise fate of these compounds is unclear. Because they are water soluble, the potential exists for slow release into sedimentary pore-waters and reintroduction into bottom-waters by resuspension or bioturbation, which increases their availability to marine organisms.

TABLE 2-2. TRACE METAL CONCENTRATIONS IN DRILLING MUDS DISCHARGED IN ALASKAN WATERS

Metal	Generic[a] Muds (mg/kg dry)	Drilling Muds Discharged to Alaskan Waters[b] (mg/kg dry) (n = 168)		
		Median[c]	Minimum[c]	Maximum
Arsenic	17.2	2.8	1.2	7.9
Barium	1,240	62,300	7	495,000
Cadmium	0.7	0.38	0.001	12
Chromium	908	130	0.5	1820
Copper	77.3	30	2.0	86.5
Lead	52.5	23.5	0.05	1270
Mercury	0.7	0.103	0.001	1.46
Nickel	9.8	NA	NA	NA
Zinc	90.4	168.5	1.0	3420

NA = Data not available.

[a] CENTEC (1984). The muds were hot-rolled prior to analysis to simulate chemical changes induced by downhole conditions (Jones and Stokes 1990, p. 14).

[b] Source: U.S. EPA Region X database. Includes all mud data except those reported in format inconsistent with permit requirements (i.e., mg/L). Data are from generic mud types (n=140), non-generic mud types (n=9) and unspecified mud types (n=19).

[c] One-half detection limit (when available) was used for those samples reported as not detected.

TABLE 2-3. COMPARISON OF THE RANGE OF TRACE METAL CONCENTRATIONS IN DRILLING MUDS DISCHARGED IN ALASKAN WATERS AND AVERAGE EARTH'S CONTINENTAL CRUST

Metal	Drilling Muds[a]	Continental Crust[b]
	Metal Concentration in mg/kg dry weight	
Arsenic	7.9	1.8
Barium	495,000	425
Cadmium	12	0.15
Chromium	1,820	120
Copper	86.5	60
Lead	1,270	14
Mercury	1.46	0.08
Nickel	NA	84
Zinc	3,420	70

NA = Data not available.

[a]Data from Table 2.

[b]Ronov and Yaroshevsky 1972, pp. 252-254.

2.2.3 Specialty Additives

In addition to the substances comprising the six generic mud types approved for use by the EPA (see Table 2-1), a group of downhole additives are used for specific problems that may be encountered during drilling. These additives include a wide range of substances, ranging from simple inorganic salts to complex organic polymers. Table 2-4 lists the more common additives authorized for use in water-based muds. Among the additives used in large enough quantities to result in substantial mass loadings to the environment are spotting materials, lubricants, zinc compounds, and materials added to prevent loss of circulation (Jones & Stokes 1989b, p. 16).

2.2.3.1 Spotting Compounds. Spotting compounds are used to help free stuck drill strings. Some of these (e.g., vegetable oil or fatty acid glycerol) are easily broken down in the environment. The most effective and, consequently, most frequently used compounds are oil-based. The discharge of muds and cuttings contaminated by diesel oil spots or oil-based muds is prohibited. However, previous oil and gas exploration NPDES permits have authorized, with restrictions, the use of mineral oil as a spotting agent (U.S. EPA 1988c). The discharge of residual amounts of mineral oil pills is authorized in recent permits provided that the mineral oil pill and at least a 50 barrel buffer of drilling fluid is removed from the system and not discharged. The residual mineral oil content should not exceed 2 percent (v/v). The above requirements have been imposed on Alaskan exploratory operations since 1985.

Mineral oils can contribute potentially toxic organic pollutants to drilling muds to which they are added. Table 2-5 presents chemical analyses of two generic drilling muds to which 1 percent, 5 percent, and 10 percent mineral oils were added (CENTEC 1984). These data show that the concentration of organic pollutants in the drilling muds is roughly proportional to the amount of mineral oil added. Table 2-6 presents the chemical analyses of three different mineral oils (Battelle 1984). Alkylated biphenyls were detected in all three mineral oils; naphthalene, fluorene, phenanthrene, alkylated benzenes, alkylated naphthalenes, alkylated fluorenes, alkylated phenanthrenes, alkylated biphenyls, and alkylated dibenzothiaphenes were detected in one or more of the oils. Naphthalene is the only one of the individual compounds detected for which Federal marine water quality criteria exist.

2.2.3.2 Lubricants. Lubricants are added to the drilling mud when high torque conditions are encountered on the drillstring. These can be vegetable, paraffinic, or asphaltic-based compounds such as Soltex. When needed, these lubricants are used to treat the entire mud system [roughly 32,000 L

TABLE 2-4. AUTHORIZED MUD COMPONENTS/SPECIALTY ADDITIVES IN COOK INLET/GULF OF ALASKA GENERAL PERMIT
(Page 1 of 3)

Product Name	Generic Description[a]	Maximum Allowable Concentration (lb/bbl Unless Otherwise Noted)[b]
Aktaflow-S	Aqueous solution of nonionic modified phenol (equivalent of DMS)	3 (3)[b]
Aluminum stearate	--	0.2
Ammonium nitrate	--	200 mg/L nitrate or 0.05 lb/bbl
Aqua-Spot	Sulfonated vegetable ester formulation	1 percent by volume
Bara Brine Defoam	Dimethyl polysiloxane in an aqueous emulsion	0.1
Ben-Ex	Vinyl acetate/maleic anhydride copolymer	1 (1)[b]
Bit Lube II	Fatty acid esters and alkyl phenolic sulfides in a solvent base	2
Calcium carbide	--	As needed
Cellophane flakes	--	As needed
Chemtrol-X	Polymer-treated humate	5 (4)[b]
Con Det	Water solution of anionic surfactants	0.4 (0.25)[b]
D-D	Blend of surfactants	0.5 (0.25)[b]
DMS	Aqueous solution of nonionic modified phenol	3 (3)[b]
Desco CF	Chrome-free organic mud thinner containing sulfomethylated tannin	0.5
Duovis	Xanthan gum	2
Durenex	Lignite/resin blend	6 (4)[b]
Flakes of silicate mineral mica	--	45
Gelex	Sodium polyacrylate and polyacrylamide	1 (1)[b]
Glass beads	--	8
LD-8	Aluminum stearate in propoxylated oleylalcohol	10 gal/1,500 bbl
Lube-106	Oleates in mixed alcohols	2
Lubri-Sal	Vegetable ester formulation	2.0 percent by volume
MD (IMCO)	Fatty acid ester	0.25 (0.25)[b]

TABLE 2-4. AUTHORIZED MUD COMPONENTS/SPECIALTY ADDITIVES IN COOK INLET/GULF OF ALASKA GENERAL PERMIT
(Page 2 of 3)

Product Name	Generic Description[a]	Maximum Allowable Concentration (lb/bbl Unless Otherwise Noted)[b]
Milchem MD	Ethoxylated alcohol formulation	0.04 gal/bbl or 0.3 (0.25) lb/bbl[b]
Mil-Gard	Basic zinc carbonate	As needed
Nut hulls, crushed granular	--	As needed
Phosphoric acid esters and triethanolamine	--	0.4
Plastic spheres	--	8
Poly RX	Polymer treated humate	4 (4)[b]
Resinex	Reacted phenol-formaldehyde-urea resin containing no free phenol, urea, or formaldehyde	4 (4)[b]
Selec-Floc	High molecular weight polyacrylamide polymer packaging in light mineral oil	0.25
Sodium chloride	--	50,000 mg/L chloride
Sodium nitrate	--	200 mg/L nitrate or 0.05 lb/bbl
Sodium polyphosphate	--	0.5
Soltex	Sulfonated asphalt residuum	6
Sulf-X ES	Zinc oxide	As needed
Therma Check	Sulfono-acylamide copolymer	1
Therma Thin	Polycarboxylic acid salt	4
Torq-Trim II	Liquid triglycerides in vegetable oil	6
Vegetable oil plus polymer fibers, flakes, and granules	--	50
VG-69	Organophilic clay	12
XC Polymer	Xanthan gum polymer	2
XO_2	Ammonium bisulfite	0.5
Zinc carbonate and lime	--	As needed

TABLE 2-4. AUTHORIZED MUD COMPONENTS/SPECIALTY ADDITIVES IN COOK INLET/GULF OF ALASKA GENERAL PERMIT
(Page 3 of 3)

[a] Any proprietary formulation that contains a substance which is an intentional component of the formulation, other than those specifically described, must be authorized by the Director.

[b] If a listed product will be used in combination with other functionally equivalent products, the maximum allowable concentration (MAC) for the sum of all of the products is the lowest MAC for any of the individual products. Four examples of functionally equivalent products are:

1) Aktaflo-S and DMS, MAC = 3 lb/bbl
2) Ben-Ex and Gelex, MAC = 1 lb/bbl
3) Chemtrol-X, Durenex, Poly RX, and Resinex, MAC = 4 lb/bbl
4) Con Det, D-D, MD (IMCO), and Milchem MD, MAC = 0.25 lb/bbl

For these examples, the MAC for any combination of the products is given in parentheses. For guidance on whether other products are considered to be functional equivalents, contact the region office of EPA.

Source: U.S. EPA (1986). General NPDES Permit No. AKG285000.

TABLE 2-5. CONCENTRATION OF ORGANIC POLLUTANTS IN TWO TYPES OF GENERIC MUDS					
Generic Mud (% Mineral Oil)	Organic Pollutants in Generic Muds (mg/kg dry weight)				
	Phenanthrene	Dibenzofuran	N-Dodecane	Diphenylamine	Biphenyl
2 (0)	--	--	--	--	--
2 (1)	1.1	--	0.7	--	--
2 (5)	8.3	0.8	6.5	--	0.9
2 (10)	19.3	1.0	13.3	4.3	2.3
8 (0)	--	--	0.8	--	--
8 (1)	--	--	--	--	--
8 (5)	5.6	--	9.4	--	--
8 (10)	11.1	0.9	8.7	--	1.1

-- = Not detected.

Source: CENTEC (1984).

TABLE 2-6. CONCENTRATION OF ORGANIC POLLUTANTS IN THREE MINERAL OILS

Pollutant	Concentration in Oils (mg/kg)		
	Oil A	Oil B	Oil C
Benzene	ND	ND	ND
Ethylbenzene	ND	ND	ND
Naphthalene	50	ND	ND
Fluorene	ND	150	10
Phenanthrene	ND	200	40
Phenol	ND	ND	ND
Alkylated benzenes	30,000	ND	ND
Alkylated naphthalenes	280	690	ND
Alkylated fluorenes	ND	1,740	ND
Alkylated phenanthrenes	ND	140	ND
Alkylated phenols	ND	ND	ND
Alkylated biphenyls	230	5,570	20
Alkylated dibenzothiaphenes	ND	370,000	ND
Aromatic content (%)	10,700	2,100	3,200

ND = Not detected.

Source: Battelle (1984).

(8,453 gal)] and are discharged into receiving waters along with the muds (U.S. EPA 1984a, p. 19). This can result in a 746-1,493 kg (1,650-3,300 lb) mass loading of the substances into the environment for each treatment of the system (U.S. EPA 1986, pp. 2-17 to 2-19). Mineral oils, mentioned above, may also be used as lubricants and may, therefore, contribute to organic pollutant loading.

2.2.3.3 Zinc Carbonate. Zinc carbonate is used as a sulfide scavenger when formations containing hydrogen sulfide are expected to be encountered during drilling. Typically the entire mud system is treated with zinc carbonate to achieve mud concentrations of zinc between 1.5 and 5.5 kg/m^3 (0.01-0.05 lb/gal), resulting in 240-940 kg (520-2,080 lb) of zinc in the mud system (Jones & Stokes 1989a, p. 20). The zinc sulfide and unreactive zinc compounds are discharged with the drilling mud into the environment, thus contributing to the overall loading of zinc.

2.2.3.4 Other Materials. In cases when circulation of the mud system is lost, combinations of cellophane, mica, and walnut hulls, or other inert substances such as vegetable and polymer fibers, flakes, granules, and glass or plastic spheres may be added to the mud in one of two methods. The entire system can be treated with typically 0.2 to 2.0 kg (0.5-5.0 lb) per barrel (bbl) of mud, which results in 220 to 2,200 kg (1,000 to 10,000 lb) of additives to the system. Alternatively, a pill of 15,899-31,797 L (4,200-8,400 gal) containing 57-170 g/L of additive (0.5-1.4 lb/gal) can be sent downhole (U.S. EPA 1984b, p. 19). When drilling resumes, the additives are separated from the drilling muds by screening and discharged into the environment along with the cuttings.

2.3 QUANTITY OF DRILLING MUDS AND CUTTINGS

2.3.1 Production Per Well

Each exploratory well in the Cook Inlet/Shelikof Strait Planning Area is expected to produce about 327 dry metric tons [mt (360 short tons)] of drilling mud and Shelikof Strait 399 dry mt (440 short tons) of cuttings (Jones and Stokes 1993). Using these estimates for muds and cuttings production, annual mass loadings have been computed for each of the three resource development scenarios (low, base, and industry alternative scenario) and are presented in Table 2-7.

TABLE 2-7. ESTIMATED ANNUAL PRODUCTION OF DRILLING MUDS AND CUTTINGS DURING EXPLORATION AND DELINEATION ACTIVITIES IN THE COOK INLET/SHELIKOF STRAIT REGION LEASE SALE 149[a]

	Year	Exploration[b]				Delineation[c]		
		Number of Rigs	Number of Wells	Mud (mt)	Cuttings (mt)	Number of Wells	Mud (mt)	Cuttings (mt)
Low Case	1995	0	2	654	798	0	0	0
	1996	0	1	327	399	0	0	0
	Total	0	3	981	1,197	0	0	0
Base Case	1995	1	2	654	798	0	0	0
	1996	1	2	654	798	1	309	363
	1997	1	2	654	798	1	309	363
	Total	3	6	1,962	7,430	2	618	726
Industry Alternative Scenario	1995	1	2	654	798	0	0	0
	1996	1	2	654	798	1	309	363
	1997	1	2	654	798	1	309	363
	Total	3	6	1,962	2,394	2	618	726

[a] Estimated number of wells and hypothetical drilling schedule.

[b] The average exploration well is assumed to use 327 mt (360 short tons) of dry mud and produce 399 mt (440 short tons) of cuttings.

[c] The average delineation well is assumed to use 309 mt (341 short tons) of dry mud and produce 363 mt (400 short tons) of cuttings.

Source: Jones and Stokes Associates (1993).

2.3.2 Rate of Discharge of Mud and Cuttings During Well Operation

The discharge rate of mud and cuttings during well drilling operations is quite variable. During actual drilling and circulation of the drilling mud, cuttings are brought up from the hole, removed by the solids control equipment (approximately 90 to 95 percent efficient), and discharged on a relatively continuous basis. However, muds are discharged less regularly (U.S. EPA 1984a, p. 23). Drilling muds are discharged in bulk when the mud type is changed or altered during cementing operations, or at the end of drilling. Bulk discharge rates reportedly range from 4,769 to 190,779 L/h [30 to 1,200 bbl/h (1,260 to 50,400 gal/h)], with total volumes discharged ranging from 15,898 L [100 bbl (4,200 gal)] to more than 317,966 L [2,000 bbl (84,000 gal)] (U.S. EPA 1984a, p. 33). The maximum discharge rate of muds and cuttings allowed in the existing Cook Inlet NPDES permit is 158,980 L/h [1,000 bbl/h (42,000 gal/h)] (U.S. EPA 1988d).

2.4 MINOR POLLUTANTS

The existing NPDES General permit for the Cook Inlet/Shelikof Strait Planning Areas authorizes the discharge of 21 different waste streams (U.S. EPA 1988d). The major waste streams, drilling mud and drill cuttings, have been discussed above. Monitoring requirements for the discharge of the other 19 waste streams generally include a monthly estimate of volume discharged. Discharge monitoring reports (DMRs) for the exploratory oil and gas drilling wells in operation during the current permit period were not available for this review. However, DMRs for the eleven wells in operation from 1990 to 1993 within the Beaufort Sea and Chukchi Sea Planning Areas have been summarized by U.S. EPA for each of the "minor" waste streams (Byar, A., 28 May 1993, personal communication). The summary of these data is reproduced in Appendix A. Summary statistics are given below for each of the waste streams. It is assumed that discharge volumes for these minor pollutants are representative of those that may occur in the Cook Inlet.

2.4.1 Sanitary Waste Discharges

Sanitary waste consists of primary and possibly secondary treated chlorinated effluent. Discharge of sanitary waste from six Beaufort/Chukchi exploratory wells in operation during the current permit period averaged 2,470,000 L/day (650,000 gal/day). The mean value was considerably elevated by one well, ARCO Fireweed (DMR9), which reported a discharge four orders of magnitude greater than the other wells. The mean of the other data points was 20,820 L/day (5,500 gal/day). This value is four times higher than the discharge predicted by Menzie (1982, p. 455), which was expected to be less than 5,300 L/day (1,400 gal/day) per drilling rig.

The current Cook Inlet NPDES permit stipulates that these discharges are required to have a chlorine residual concentration as close as possible to, but no less than, 1.0 mg/L (U.S. EPA 1986c). All but one of the eight wells in the Beaufort Sea and Chukchi Sea Planning Areas which reported residual chlorine data satisfied this requirement [(range 1.5-1.9 mg/L) (excluding DMR9 data)] (Appendix A).

The main concern associated with sanitary waste discharge is the extent of reduction in ambient dissolved oxygen concentrations in receiving waters, particularly when discharge occurs under the ice. Based on an analysis of a "worst-case" scenario, using the methodology described in Tetra Tech (1982), U.S. EPA (1984a) concluded that discharge of treated sewage effluent during offshore exploratory drilling should not significantly impact aquatic life when ambient dissolved oxygen concentrations are at least 1 mg/L above the dissolved oxygen standard for aquatic life, usually 6 mg/L (Jones & Stokes 1989a, p. 9). Since the ambient dissolved oxygen concentration in receiving waters is assumed to exceed 8 mg/L (Jones & Stokes 1984, p. 8), discharge of domestic sewage effluent is not expected to substantially impact dissolved oxygen concentrations in the ocean.

2.4.2 Domestic Waste

Discharge of domestic waste (shower and sink drainage) from two Beaufort/Chukchi wells in operation from 1991 to 1993 averaged 340,543 L/day (89,962 gal/day). The mean value reported by one well, DMR9, was considered to be suspect, therefore, the data point was not used. The range of discharges from these two wells is quite large [16,500-664,616 L/day (4,350-175,573 gal/day)]. The highest values (and the mean of both values) are much greater than the average discharge from an Alaskan offshore oil rig, which is usually less 30,600 L/day (8,084 gal/day)(Jones & Stokes 1989b, p. 9). This waste is sometimes reused to make drilling mud rather than being discharged directly into receiving waters. The environmental effect of these discharges is difficult to determine given the absence of any analytical data.

2.4.3 Desalination Wastewater and Boiler Blowdown

Desalination units may discharge on the order of 594,000 L/day (157,000 gal/day) (mean of data from six Beaufort/Chukchi exploratory wells, excluding DMR9 data) of seawater at salinity twice that of ambient seawater. Boiler blowdown may be discharged once or twice a year per rig in volumes of around 662 L (175 gal) [mean of five exploratory wells (excluding DMR9 data)], although discharges as high as 3,780,000 L (1,000,000 gal) have been estimated (Appendix A). Both of these discharges may contain biocides or chemicals used to retard corrosion and scaling. Discharge volumes from boiler blowdown are usually small, and will therefore not typically contribute substantially to pollutant loading. However, discharge from desalination units (and periodically discharges from boiler blowdown) could result in substantial mass loadings of pollutants into the immediate marine environment if the chemicals (biocides, corrosion inhibitors, and scaling agents) are not consumed or detoxified prior to discharge (Jones & Stokes 1989b, p. 9).

2.4.4 Test Fluids from the Well

Test fluids are discharged from the well upon completion of drilling. These may consist of formation water, vegetable or mineral oil, natural gas, formation sands, any added acids or chemicals, or any combination thereof (U.S. EPA 1985). Test fluids are generally stored and treated with acid to remove oil before being discharged. During a typical 5-day well test, approximately 1 percent, or 7,949 L (2,100 gal), of the total test fluids will have a pH of 2. The remaining 99 percent, or 771,067 L (203,694 gal), of test fluids will have a pH ranging from 5.0 to 8.5 (U.S. EPA 1988b, p. 2-6). DMR data on test fluid discharge are very limited. One well in the Beaufort Sea and Chukchi Sea Planning Areas reported a maximum value of 30,600 L (8,085 gal). The addition of strong acidic solutions downhole could cause substantial leaching of heavy metals from the formation and residual drilling mud (Jones & Stokes 1989a, p. 10). The existing Cook Inlet NPDES permit requires that the pH of this discharge be between 6 and 9, (U.S. EPA 1988d).

2.4.5 Deck Drainage

Deck drainage, which consists of precipitation, wash-water from the deck, and fire control system test water discharges, is expected to occur only during summer months due to the low Arctic temperatures. Menzie (1982, Table 1) estimated deck drainage at 53,000 L/day (14,000 gal/day). Discharge of deck drainage from six Beaufort/Chukchi exploratory wells in operation during 1990 to 1993 averaged 946,000 L/day (250,000 gal/day). The mean value was considerably elevated by one well, DMR9, which reported a discharge four orders of magnitude greater than the other wells. The mean of the other data points was 20,850 L/day (5,508 gal/day). Oil is the primary pollutant in deck drainage, with a reported range of 24 to 450 mg/L, although these discharges may also contain small quantities of detergents, spilled drilling mud, and chemicals. Gutters normally carry the drainage to a collection tank where petroleum hydrocarbons are separated and removed prior to discharge (Jones & Stokes 1990, p. 11). If the collection system is operating normally, the mass loading of pollutants to the environment should be minimal.

2.4.6 Blowout Preventer Discharge

The blowout preventer is a device designed to contain pressures in the well that cannot be contained by the drilling mud. It may be located on the sea floor or on the drilling platform. Fluid may be discharged when the blowout preventer is actuated, generally on a weekly basis for testing (Jones & Stokes 1990, p. 9). Discharge of blowout preventer fluid from four Beaufort/Chukchi exploratory wells, excluding DMR9 data, in operation during 1990 to 1993 averaged 1,790 L/day (473 gal/day), which is greater than the expected discharges reported by U.S. EPA (1984b, p. 12), which are on the order of 757 L/day (200 gal/day). The mass loading of pollutants from these intermittent discharges are expected to be minimal. The primary constituents of blowout preventer fluid are ethylene glycol and water. Ethylene glycol is not considered to be highly toxic to aquatic life. The LC_{50}s (the concentration lethal to 50 percent of the test organisms) for several warmwater fish species exceed 5,000 (Hazardous Substance Database 1992). No comparable data are available for coldwater or Alaska species. Given the minimal expected mass loading of ethylene glycol, no adverse impacts are anticipated from blowout preventer fluid discharge.

2.4.7 Miscellaneous Discharges

Other minor discharges, in addition to those listed above, may include uncontaminated ballast and bilge water, excess cement slurry, compounds used for equipment and drilling maintenance activities (e.g., waterflooding discharges, produced water, completion fluids, workover fluids, and well treatment fluids), non-contact cooling water, fire control system test water, produced solids, and muds, cuttings, and cement at the seafloor.

Bilge waters are treated to remove oil prior to discharge. If the collection system is operating normally, the mass loading of pollutants to the environment should be minimal. However, discharge of bilge water may be approximately 256,120 L/day (67,660 gal/day) for oil and gas drilling activities in the Beaufort Sea and Chukchi Sea Planning Areas so the potential impacts to the Cook Inlet/Shelikof Strait Planning Area could be significant if the collection system malfunctions. Ballast waters are not treated, but should have a composition similar to seawater unless contaminated by machinery lubricants or fuel. The existing

Cook Inlet NPDES permit prohibits the discharge of any materials that may cause a visible sheen of oil (U.S. EPA 1988d).

The volume of noncontact cooling water required for drilling operations can vary depending on the system used. Closed-system, air-cooled designs require no cooling water, whereas other systems may discharge up to 7 million L (1.87 million gal) per day. The Beaufort/Chukchi exploratory wells in operation during 1990 to 1993 reported discharges on the order of 8.5 million L (2.25 million gal) per day (Appendix A). Reported temperatures for discharged cooling water range from 15° to 25° C (62° to 84° F) (Jones & Stokes 1990, p. 11), which are substantially higher than ambient seawater. In addition to elevated temperatures, cooling water may contain biocides added to control fouling in the heat exchanger units of cooling systems (Jones & Stokes 1989a, p. 10). The substantial volumes of cooling water discharged indicates that significant mass loading of pollutants into the immediate marine environment could result if the chemicals are not consumed or detoxified prior to discharge (Jones & Stokes 1990, p. 11).

Cement, along with spud mud (see Table 2-1) and cuttings, are discharged from drillships and on the ocean floor in the early phases of drilling before the well casing is set, and during well abandonment and plugging. Excess cement slurry will result from equipment washdown after cementing operations. The exact composition and potential toxicity of cement is not documented, but it is generally expected to be nontoxic (U.S. EPA 1984a, p. 12). Discharge volumes from six exploratory wells in the Beaufort Sea and Chukchi Sea Planning Areas operating during 1990 to 1993 range from 6,700-522,387 L/day (1,770-138,000 gal/day). The large range indicates that the amount discharged is site specific. Although the composition of the cement is not well documented, it is not expected to represent a significant pollutant source (Jones & Stokes 1989a, p. 11). No adverse impacts are expected from the discharge of cement and other materials on the ocean floor.

2.5 SUMMARY

Drilling muds and cuttings are the major discharges during exploratory drilling. The preliminary draft appendix of the EIS for the Cook Inlet/Shelikof Strait Planning Area estimates that a total of 3 exploration and delineation wells will be drilled for the low resource scenario, 8 for the base resource scenario, and 8 for the industry alternative scenario. Exploration and delineation wells are expected to have an average true vertical depth (TVD) of 1,829 m (6,000 ft) and produce approximately 327 dry metric tons (360 short tons) of drilling mud and 399 dry metric tons (440 short tons) of cuttings (Jones and Stokes 1993).

Components of concern in drilling muds include trace metals and specialty additives used with generic drilling mud systems. The majority of trace metals will remain bound to particulates in the whole mud. Specialty additives could be a source of trace metals (e.g., zinc) and petroleum hydrocarbons. Mass loadings of the additives depend on the concentrations, frequency of usage, and conditions encountered during the drilling.

Substantial discharges from desalination units may result in substantial mass loadings of pollutants (biocides, corrosion inhibitors, scaling agents) into receiving waters. At present there is no information available on the potential impacts these pollutants may have on aquatic life.

3.0 TRANSPORT, PERSISTENCE, AND FATE OF MATERIALS DISCHARGED

3.1 TRANSPORT AND PERSISTENCE

Factors influencing the transport and persistence of discharged drilling muds and cuttings include oceanographic characteristics of the receiving water, characteristics of the discharge, depth of discharge, discharge rate, and method of disposal. Oceanographic considerations include tides, wind, freshwater overflow, ice movement, stratification, and current regime. Several studies conducted for other outer continental shelf locations were considered for application in this report.

3.1.1 Summary of Transport/Persistence Studies in Other OCS Lease Areas

The transport, persistence and fate of materials discharged into the marine environment from exploratory drilling operations has been evaluated for previous Cook Inlet and Shelikof Strait Lease Sale areas [e.g., Cook Inlet-Shelikof Strait OCS Sale 60 (U.S. EPA 1983), Gulf of Alaska-Cook Inlet OCS Sale 88 (U.S. EPA 1984)]. The general conclusions reached in these studies regarding the transport, dispersion, and persistence of drilling discharges are summarized below:

- The primary materials discharged during drilling activities that are of concern to the marine environment include drilling fluids (muds), specialty additives, and cuttings.

- Drilling discharge (drilling muds and the dissolved component) separates into an upper and lower plume. Physical descriptions of effluent dynamics and particle transport differ substantially for the two plumes.

- Drill cuttings (parent material from the drill hole) are generally coarse materials that are deposited rapidly following discharge and settle within the 100-m radius mixing zone.

- Drilling materials discharged to deep-water marine environments tend to be rapidly diluted and dispersed. Dilutions of particulate material on the order of 1,000 to 10,000:1 have been predicted in the upper plume at the edge of the mixing zone [100 m (330 ft)] of the discharge during OCS studies (U.S. EPA 1993, p. 23).

- The dilution of drilling materials discharged in shallow areas less than 15 m (49 ft), where the depth of the mixing zone is limited, is less than that of deeper waters. Dilutions as low as 167:1 have been measured at the edge of a 100 m (330 ft) mixing zone (U.S. EPA 1988, p. 3-2).

- Discharged drilling materials typically settle in the immediate vicinity of the discharge area. However, deposition patterns are extremely variable and are strongly influenced by several factors, including the type and quantity of mud discharged, hydrographic conditions at the time of discharge, and height above the seafloor at which discharges are made.

The items listed above provide a general overview of the results obtained for other ODCE sale locations. Modeling results for cases representative of drilling discharge conditions within the proposed Lease Sale area are presented in Section 3.1.3.

3.1.2 Oceanographic and Meteorologic Conditions Affecting Dilution and Dispersion

The oceanographic and meteorologic conditions affecting dilution and dispersion for Cook Inlet and Shelikof Strait will be briefly summarized below.

3.1.2.1 Physical Description. Lease Sale 149 includes approximately 1.5 million ha (3.7 million ac) of the Cook Inlet/Shelikof Strait Planning Area (Figure 1-1). The area encompassed within this Lease Sale extends from Cape Ikolik (approximately 57° 15'N, 154° 50'W) northward along the west coast of Kodiak Island into Cook Inlet to approximately 60° 20'N latitude, 152° 15'W longitude. The Lease Sale boundary then continues southward along the west coastline of Cook Inlet, around Augustine Island, into the Shelikof Strait to approximately 57° 30'N latitude, 152° 44'W longitude . The southern boundary of the Lease Sale area extends from this location across the Shelikof Strait to Cape Ikolik

Water depths in Lease Sale 149 range from approximately 13.5 m (44 ft) to 290 m (951 ft), with water depths tending to increase as one moves north to south within the Lease Sale area. In lower Cook Inlet, water depths generally range from 75 to 90 m (246 to 295 ft). In Shelikof Strait, most water depths range from 150 to 180 m (490 to 590 ft).

Coastal features in the waters adjacent to the Cook Inlet/Shelikof Strait Planning Area include rocky shores and seacliffs, lagoons, capes and points, and bays. The Cook Inlet is predominately surrounded by mountains except along it's southerly and southeasterly boundary where waters flow into Shelikof Strait and the Gulf of Alaska, respectively. The Shelikof Strait is bordered on the northwest by the mountains and glaciers of the Alaska Peninsula and on the southwest by the rocky coast of Kodiak Island (Jackson and Kurz 1982).

3.1.2.2 Geology. The Cook Inlet/Shelikof Strait Planning Area is located in a seismic risk zone that is susceptible to earthquakes of magnitudes 6.0 to 8.8 on the Richter scale. Damage resulting from earthquakes of these magnitudes can be caused by ground shaking, ground failure, fault displacement, surface warping, seismic seawaves (tsunamis), and consolidation of soils (U.S. DOI 1981). The planning area is also susceptible to volcanic activity as the result of plate convergence between the North American and Pacific plates. Nineteen volcanoes form the eastern Aleutian Arc from the upper Alaska Peninsula to Cook Inlet.

3.1.2.3 Meteorology. Lower Cook Inlet lies in a transition zone between continental and marine meteorological conditions, whereas Shelikof Strait and the Alaska Peninsula have meteorological conditions characteristic of maritime climate (U.S. DOI 1981).

Summer wind speeds in Cook Inlet tend to be slightly higher than in winter and are more consistent in direction (SAIC 1979). The North Pacific high pressure system dominates the area during summer bringing south to southwesterly winds and air temperatures ranging from to 10-12 °C (50 - 54 °F). In winter, the weather is controlled by the deepening Aleutian low atmospheric pressure system. Winds associated with this system are generally north to northwesterlies, resulting in low temperatures (less than 0°C) over the inlet. These conditions result in ice formation in the upper inlet. Average wind speeds over open water in Cook Inlet range from 15-25 knots with extreme speeds from 75-100 knots (U.S. EPA 1983).

Southwesterly winds moving over the open water fetch from lower Cook Inlet to Shelikof Strait can result in the development of storm surges within the Lease Sale area. West to southwesterly winds also can result in storm surges occurring in the lower Cook Inlet. All known storm surges have occurred in the fall and winter (LaBelle and Wise 1983).

3.1.2.4 Sea Ice. Ice formation in the Lease Sale area is expected to be minimal or non-existent, however, there are regions adjacent to the sale area where ice develops. Ice starts to form in upper Cook Inlet in late November and customarily breaks up by late April (LaBelle and Wise 1983). Winter winds and currents move the ice southward through the Forelands where the ice is broken up and reconsolidated to form float ice. Sea ice tends to accumulate along the western shoreline of Cook Inlet as a consequence of prevailing winds and circulation patterns (Wapora, Inc. 1979). Tidal flow provides an influx of relatively warm water twice a day and tends to move the ice to warmer areas as the tide recedes. The Alaska Coastal Current which flows from the Kennedy Entrance to southern Cook Inlet and into Shelikof Strait, limits ice formation in lower Cook Inlet and Shelikof Strait. The central and eastern portions of Cook Inlet are generally ice free (SAIC 1979). Ice forms infrequently in the northwestern area of Shelikof Strait near Cape Douglas.

As discussed in ODCE's for Lease Sales 60 and 88 (U.S. EPA 1983, p.28; U.S. EPA 1984, p.47), ice formation and stabilization in the area does not affect circulation and transport, except in smaller bays, coves, and in nearshore waters. Therefore, the presence of ice will not influence the magnitude of dilution of drilling muds discharged to the Lease Sale area (U.S. EPA 1983).

3.1.2.5 Circulation. In general, water in lower Cook Inlet moves in a counterclockwise gyre (Figure 3-1). Secondary gyres may be established in Kachemak and Kamishak Bays. The circulation patterns for the area are influenced by waters from the Gulf of Alaska (Alaska Coastal Current) and fresh water input from the Copper River and rivers of the Kenai Peninsula. Water from the Gulf of Alaska enters Kennedy and Stevenson Entrances and is diverted northward before mixing with a strong surface outflow from upper Cook Inlet.

Two important features of the circulation pattern in Cook Inlet are upwelling along the southwest shore of the Kenai Peninsula and formation of frontal zones (zones of flow convergence or "rips") as the seawater from the Gulf of Alaska encounters the freshwater outflow from the upper inlet. Water flowing

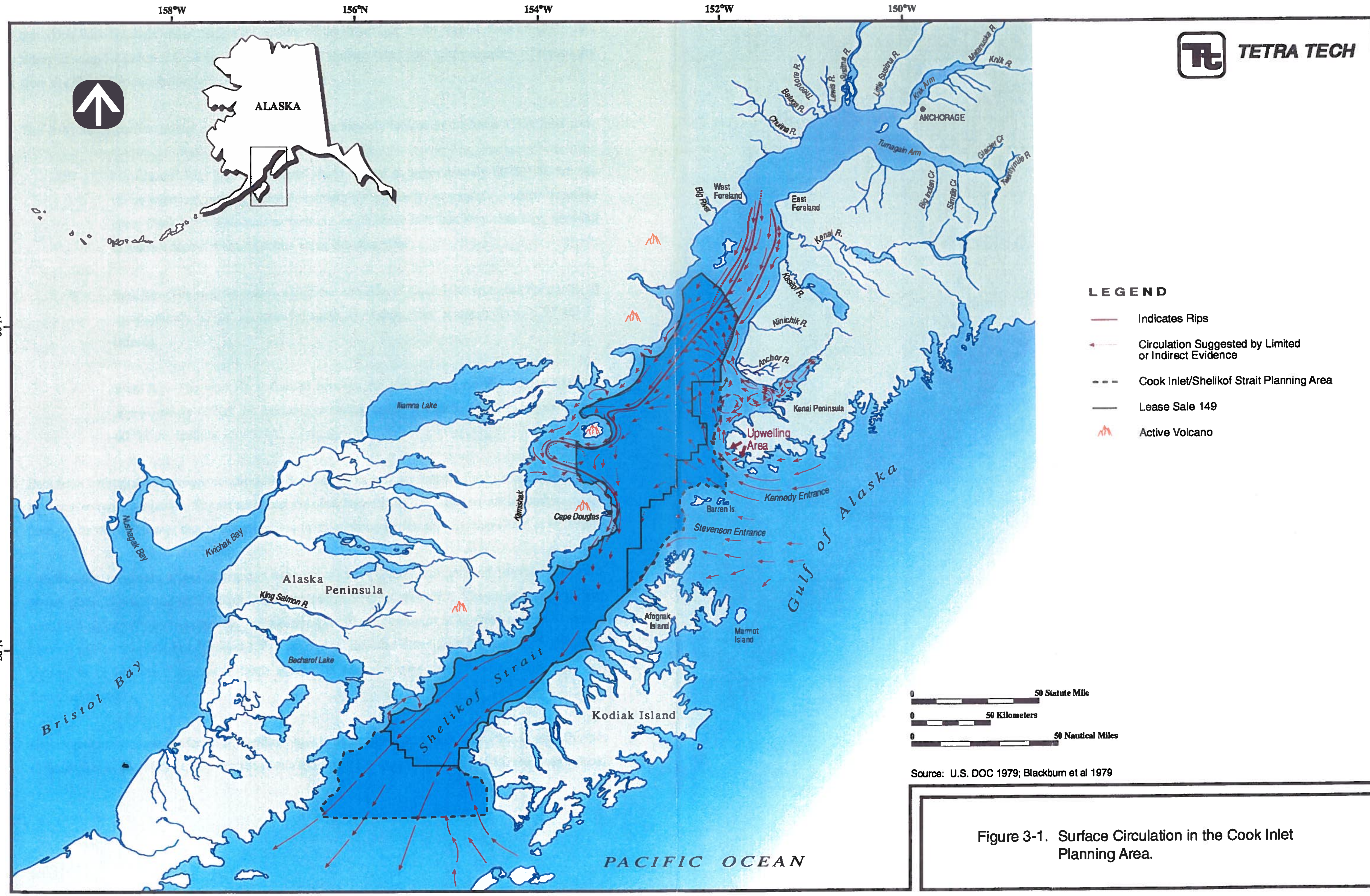


Figure 3-1. Surface Circulation in the Cook Inlet Planning Area.

into Cook Inlet descends under the fresher outflow of the upper inlet at the frontal zones (SAIC 1979). Water flowing out of lower Cook Inlet moves along the western side of the inlet and mixes with seawater from the Gulf of Alaska before entering Shelikof Strait.

The three major current frontal zones listed below are commonly formed in the lower Cook Inlet area:

- Mid-channel Rip- The mid-channel rip is formed at approximately 60°50' N. latitude where westward moving water flow meets the southerly, low salinity outflow from the upper Cook Inlet. This zone extends the length of the inlet into Kamishak Bay, resulting in heavy accumulations of debris along the shoreline.

- East Rip- The east rip occurs along the east side of Cook Inlet from the Forelands, at approximately 60°44' N. latitude, south to Anchor Point at approximately 59°45' N. latitude.

- West Rip- The west rip is formed between the mid-channel rip and Kalgin Island at approximately 60°45' N. latitude, extending south of Chisik Island to approximately 60°03' N. latitude.

Data from hydrographic surveys conducted in Shelikof Strait indicate that the flow pattern is similar to an estuarine-type circulation. The net surface circulation through Shelikof Strait results in southwestward flow, while the net flow at deeper depths moves in an opposite northward direction (Reed et al. 1987).

Conductivity, temperature, and density data was used to derive volume transport and distribution of near-bottom physical properties for Shelikof Strait from March 1985 to June 1987. The mean water transport was 0.6×10^6 m^3 s^{-1} to the southwest. Ekman transport (the net transport of surface water set in motion by wind and theoretically in a direction 90° to the right of the wind direction in the northern hemisphere) appears to be important in creating large changes in transport over short time intervals (Reed and Schumacher 1989).

Other studies have been conducted in Shelikof Strait to determine transport in the Alaska Coastal Current (Schumacher et al. 1989). Using current observations from August 1984 to July 1985, the mean volume transport through the Shelikof Strait sea valley was calculated to be 0.85 x 10^6 m^3/sec. The data showed an increased volume transport coinciding with maximum freshwater discharges in autumn, although the greatest increase in volume transport occurred in winter, principally due to wind forcing (Schumacher et al. 1989).

3.1.2.6 Currents. Currents in Cook Inlet are dominated by tidal influences and meteorological events. Inflowing waters from the Gulf of Alaska have mean current speeds of 10-15 cm/sec during the summer months, which increase to 25-30 cm/sec during the winter months. Current speeds of 15-20 cm/sec have been noted in the summer for southerly flowing waters moving out of the upper inlet. These speeds decrease in the winter to approximately 10 cm/sec (U.S. DOI 1984).

Shelikof Strait has semi-daily tidal currents which are slightly weaker inshore near the Alaska Peninsula than in deeper water offshore (Reed and Stabeno, 1993). The mean current speeds in the main channel of Shelikof Strait are estimated to be approximately 13-26 cm/sec (Reed et al. 1987). More detailed information on current speeds is presented in Sale 88 ODCE (U.S.EPA 1984 p.43).

3.1.2.7 Tides. The main force affecting surface circulation in Cook Inlet and Shelikof Strait is semidiurnal unequal tides. Typical ranges between successive high and low waters are 3.7 to 5.5 m (12 to 18 ft). The greatest tidal range occurs in upper Cook Inlet (U.S. DOI 1981). The mean tidal ranges along the western shore of lower Cook Inlet increase to the north. Tidal ranges on the eastern side are generally 0.61-1.22 m (2-4 ft) greater than those on the western side due to the Coriolis effect (SAIC 1979). In Shelikof Strait, the tide floods from both ends of the strait. The ebb current flow moves to the southwest.

Tidal currents reach 2-3 knots at the entrance to lower Cook Inlet and strong tidal currents exist along the eastern part of lower Cook Inlet north of Anchor Point. The weakest tidal currents are located southeast of Augustine Island.

3.1.2.8 Salinity and Temperature. Seasonal changes in temperature and salinity in Cook Inlet are dependent upon freshwater input. Upper inlet waters are diluted with fresh water from the rivers entering the northern inlet. Salinities of approximately 32.0 ppt are observed throughout the summer near Kennedy Entrance. Salinities along the western portion of the inlet are approximately 26.5 ppt. The water entering Cook Inlet and Shelikof Strait from the Gulf of Alaska is generally warmer and more saline than waters from the upper inlet. Detailed information concerning salinity and temperature is given in the Sale 60 ODCE (U.S.EPA 1983, p.27).

3.1.2.9 ***Sediment Transport.*** Sediment transport in lower Cook Inlet and Shelikof Strait follows the general counterclockwise circulation pattern. Suspended particulate matter from the upper inlet passes through the lower inlet with little or no deposition, except in coastal embayments such as Kamishak Bay (Feely et al. 1981; Feely and Massoth 1984). In Shelikof Strait, sediment cores collected in the northern and southern portions of the strait showed sediment accumulation rates of approximately 8.8 g $m^{-2}d^{-1}$ and 20 g $m^{-2}d^{-1}$, respectively (Feely et al. 1981). In the southwestern region of Shelikof Strait, sediment is accumulating more rapidly, at a rate of up to 20 centimeters per 100 years in sea floor depressions. The horizontal gradient of suspended solids is controlled primarily by sediment resuspension from strong tidal currents and dilution by inflowing seawater from the Gulf of Alaska.

Extensive sand transport has been observed in lower Cook Inlet. Sand waves with amplitudes of 2 meters (6.6 ft) have been found in this area (U.S. DOI 1984).

3.1.3 Modeling of Drilling Mud Transport, Deposition, and Dilution

Prediction of the fate of discharged muds and cuttings from exploratory oil drilling relies on a computer model developed by the Offshore Operators Committee (OOC) and Exxon Production Research Company, and is based on the U.S. Army Corps of Engineers/Environmental Protection Agency Dredge Spoil Model (Brandsma et al. 1980). The OOC model considers the drilling discharge plume to be divided into an upper plume, which contains fine-grained and soluble components, and a lower plume, which contains the majority of solids. The dilution of the drilling effluent is simulated by considering three phases of plume behavior: convective descent, dynamic collapse, and a later passive diffusion phase. A Gaussian formulation is used to sum the three component phases and to track the distribution of solids to the bottom. The model predicts concentrations of solids and soluble components in the water column and the initial deposition of solids on the seafloor.

The OOC model results do not include cuttings. These are expected to be of coarser grain size than muds and will, therefore, settle rapidly to the seafloor. Jones & Stokes (1989b, p. 38) indicate that the majority of cuttings will probably be deposited within 100-m (330-ft) from the point of discharge at all depths and current speeds. The total dry weight discharge of cuttings is generally about 1.3 times greater than the total discharge of drilling muds for exploratory drilling operations. Thus, nearfield estimates (within 100 m of the point of discharge) of bottom accumulations of drilling mud substantially underestimate the total deposition of material from drilling discharges.

The OOC model has undergone continuous modification to improve its capabilities and ease of use, and has been calibrated using field measurements taken at several continental shelf drilling sites, including the Gulf of Alaska, Gulf of Mexico, and off the eastern and western U.S. coasts (U.S. EPA 1984b; O'Reilly et al. 1989). Comparison of model results with field observations indicates the model is capable of predicting many important aspects of plume behavior. However, the model makes several simplifying assumptions that may vary from actual conditions at any given site (e.g., a single discharge of limited duration and unidirectional currents). Therefore, the model predictions discussed below provide a generalized picture of expected dilution and deposition of drilling muds.

The OOC model (Version 1.0) was used to examine discharge scenarios that were 1) likely to occur in the Lease Sale area, and 2) representative of the maximum allowable discharges. Discharge scenarios were determined by examining relevant information sources describing exploratory oil and gas drilling practices. Maximum allowable discharges are those specified in the National Pollutant Discharge Elimination System (NPDES) general permit for oil and gas exploration facilities on the outer continental shelf (Permit Number AKG285000). This permit is applicable to discharges from drilling rigs in the Cook Inlet/Shelikof Strait Planning Area. With reference to drilling mud discharges, the permit states that:

"the total drilling muds, drill cuttings, and washwater discharge rate shall not exceed:

(a) 1,000 bbl/hour in water depths exceeding 40 m

(b) 750 bbl/hour in water depths greater than 20 m to 40 m

(c) 500 bbl/hour in water depths 5 m to 20 m

Discharge of muds and cuttings is prohibited between the shore (mainland and island) and the 5 m isobath."

In addition to the depth-related discharge requirements, the general NPDES permit for oil and gas exploration also specifies the following areas where discharges are prohibited:

- Within the boundaries or within 1,000 m (3,280 ft) of a coastal marsh, river delta, river mouth, designated Area Meriting Special Attention, game refuge, game sanctuary, or critical habitat area

- In Kamishak Bay west of a line from Cape Douglas to Chinitna Point.

- In Chinitna Bay inside the line between the points on the shoreline at latitude 59°52'45"N, longitude 152°48'18"W on the north and latitude 59°46'12"N, longitude 153°00'24"W on the south.

- In Tuxedni Bay inside the lines on either side of Chisik Island.

The estimate of the average amount of drilling muds and cuttings produced by each exploratory well is based on the predicted average depth necessary for each well. The average exploratory well depth for the Cook Inlet/Shelikof Strait Planning Area is predicted to be 1,828 m (6,000 ft) (Jones and Stokes 1993). Based on this average drilling depth, it is estimated that the average exploratory well will produce 327 metric tons (360 tons) of dry drilling muds and 399 metric tons (340 tons) of dry rock cuttings (Jones and Stokes 1993).

Since each actual exploratory well drilled will be unique, it can be assumed that the actual quantity of drilling muds produced will vary for each individual well. Since the dilution of the discharged mud is primarily a function of the discharge rate, and not of the total mass discharged, variation in the total amount of drilling muds discharged will not affect the predicted dilutions of dissolved and solid components in the water column. However, variation in the total amount of drilling mud discharged will affect the model-predicted depth of sediments deposited on the bottom. Therefore, the model-predicted maximum sediment depths for a range of total drilling muds discharged (25 to 500 percent of the average value) will also be explored. This will assist in the evaluation of the potential smothering effect of these various discharge scenarios on benthic organisms that occur within Lease Sale 149 (Section 5.2).

OOC model test cases that reflect the permit stipulations discussed above were run for open-water discharges; results of the model runs are discussed below.

3.1.3.1 Open-Water Discharges. During a typical year, ice is minimal or non-existent in the Lease Sale area, therefore, discharge into open water is possible.

Open-water discharges were modeled for six depth and discharge combinations. Model parameters held constant for all test cases are given in Table 3-1. OOC model predictions for the open-water discharge test cases are shown in Table 3-2. These test cases reflect the maximum discharge rates allowed by the NPDES general permit in different water greater than depths [1,000 bbl/h (159,091 L/h) in water greater than 40 m (131 ft) deep, 750 bbl/h (119,318 L/h) in water greater than 20 m (66 ft) deep to 40 m, and 500 bbl/h (79,545 L/h) in water 5 m (16 ft) to 20 m deep. Discharge to waters less than 5 m deep is prohibited by the general NPDES permit for oil and gas exploration; therefore, this discharge scenario was not modeled. All model runs assume a one hour discharge of muds that have an initial solids concentration of 1.44 kg/L (505 lb/bbl). Three unidirectional current speeds of 10 cm/sec (0.33 ft/sec), 20 cm/sec (0.66 ft/sec), and 32 cm/sec (1.05 ft/sec) were evaluated for each water depth.

Modeling reports on the fate and effects of exploratory drilling discharges for Alaskan OCS Lease Sale areas (e.g., Jones and Stokes 1989b, 1990) have estimated the thickness of drilling mud deposition by multiplying modeling-derived sediment deposition values by a factor (e.g., 2.6) to reflect the higher mud discharges expected during drilling a well. This method of estimating mud accumulation assumes that areal deposition patterns will be unchanged for discharges of different quantities of mud and is reasonable provided that the rate of mud discharge does not vary from that predicted in the modeling. Mud deposition depths shown in Table 3-2 are the depths expected to occur after completion of an average exploratory well.

40-m Water Depth. Modeling results for the maximum allowable discharge rate in a water depth of 40 m (131 ft) and a current speed of 10 cm/sec resulted in a minimum solids dilution at 100 m (328 ft) of 905:1. The minimum dissolved dilution at 100 m was 1,285:1. The maximum depth of deposited mud [1.2 cm (0.47 in)] occurred approximately 61 m (200 ft) downcurrent from the point of discharge. The depth of mud deposition at the edge of the mixing zone (100 m from the point of discharge) was

TABLE 3-1. OOC MODEL INPUT PARAMETERS HELD CONSTANT

Discharge Conditions	
Duration (hr)	1.0
Angle of Pipe (Degrees Downward From Horizontal)	90.0
Depth Of Pipe Mouth (m)	0.3
Pipe Radius (m)	0.1
Rig Type	Jackup
Rig Length (m)	70.1
Rig Width (m)	61.0
Rig Wake Effect	Included
Drilling Mud Characteristics	
Bulk Density (g/cm^3)	2.085
Initial Solids Concentration in Whole Mud (mg/l)	1,441,140

Mud Particle Distribution

Class No.	Density (g/cm^3)	Volume Fraction In Whole Mud (cm^3/cm^3)	Settling Velocity (cm/sec)	Settling Velocity (ft/sec)
1	3.959	0.0364	0.658	0.021600
2	3.959	0.0364	0.208	0.006820
3	3.959	0.0437	0.085	0.002780
4	3.959	0.0728	0.044	0.001430
5	3.959	0.1383	0.023	0.000758
6	3.959	0.0364	0.013	0.000427

Receiving Water Characteristics	
Significant Wave Height (m)	0.6
Significant Wave Period (sec)	12.0
Surface Water Density (σ_t)	22.0
Density Gradient ($\Delta\sigma_t$/m)	+0.1

Source: Tetra Tech (1993).

TABLE 3-2. SUMMARY OF OOC MODEL RESULTS FOR OPEN-WATER DISCHARGE TEST CASES REPRESENTATIVE OF THE LEASE SALE AREAS

Modeling Test Case	3	NA*	15	16	NA*	17
Water Depth	40 m	40 m	70 m	120 m	120 m	120 m
Discharge Rate	1,000 bbl/h (159,091 L/h)	1,000 bbl/h (159,091 L/h)	1,000 bbl/h (159,091 L/h)	1,000 bbl/h (159,091 L/h)	1,000 bbl/h (159,091 L/h)	1,000 bbl/h (159,091 L/h)
Unidirectional Current Speed (cm/sec)	10	20	10	10	20	32
Minimum Solids Dilution at 100 m	905:1	ND	1,803:1	1,437:1	ND	5,793:1
Minimum Dissolved Dilution at 100 m	1,285:1	ND	2,702:1	2,503:1	ND	9,127:1
Maximum Depth of Deposited Mud (cm)	1.2	7.1	0.05	0.17	1.0	0.004
Estimated Distance from Discharge for Maximum Mud Depth (m)	61	220	61	183	500	3,200
Estimated Mud Deposition Depth at Edge of Mixing Zone (cm)[a]	0.77[b]	4.8	0.034[c]	0.057[c]	0	0
Estimated Percentage of Discharged Solids Deposited Within the Mixing Zone[a]	67[b]	ND	33[c]	17[c]	0	0

[a] Mixing zone is defined as 100 m from the point of discharge.

[b] 91.4 m from the point of discharge.

[c] 121.9 m from the point of discharge.

NA = Not applicable.

ND = Data not available.

Source: Tetra Tech (1993).

* Jones & Stokes (1993).

0.77 cm (0.30 in). The OOC model estimated that approximately 67 percent of the discharged solids would be deposited within the 100 m (328 ft) mixing zone (Table 3-2).

Modeling results for the maximum allowable discharge rate occurring in a water depth of 40 m (131 ft) and a current speed of 20 cm/sec show that the maximum depth of deposited mud [7.1 cm (18.1 in)] occurred approximately 220 m (66 ft) downcurrent from the point of discharge. The depth of mud deposition at the edge of the mixing zone was 4.8 cm (2.3 in) (Table 3-2).

70-m Water Depth. Model results for the maximum allowable discharge rate in a water depth of 70 m (230 ft) and a current speed of 10 cm/sec resulted in a minimum solids dilution at 100 m (328 ft) of 1,803:1. The minimum dissolved-component dilution at 100 m (328 ft) was 2,702:1. The maximum depth of deposited mud [0.05 cm (0.02 in)] occurred approximately 61 m (200 ft) downcurrent from the point of discharge. The mud deposition depth at the edge of the mixing zone was 0.034 cm (0.01 in). The OOC model estimated that approximately 33 percent of the discharged solids would be deposited within the 100 m (328 ft) mixing zone (Table 3-2).

120-m Water Depth. Model results for the maximum allowable discharge rate at a depth of 120 m (394 ft) and a current speed of 10 cm/sec resulted in a minimum solids dilution at 100 m of 1,437:1. The minimum dissolved-component dilution at 100 m was 2,503:1. The maximum depth of deposited mud [0.17 cm (0.07 in)] occurred approximately 183 m (600 ft) downcurrent from the point of discharge. The OOC model estimated that approximately 17 percent of the discharged solids would be deposited within the 100 m (328 ft) mixing zone (Table 3-2).

Model results for maximum allowable discharge rate in a water depth of 120 m (394 ft) and a current speed of 20 cm/sec show that the maximum depth of deposited mud [1.0 cm (0.39 in)] occurred approximately 500 m (1,640 ft) downcurrent from the point of discharge. No drilling muds are predicted to be deposited within the mixing zone for this model scenario (Table 3-2).

Model results for the maximum allowable discharge rate at a depth of 120 m (394 ft) and a current speed of 32 cm/sec resulted in a minimum solids dilution of 5,793:1 at 100 m and a minimum dissolved-fraction dilution of 9,127:1 at 100 m (328 ft). The maximum depth of deposited mud [0.004 cm (0.002 in)] occurred approximately 3,200 m (10,499 ft) downcurrent from the point of discharge. No drilling muds are predicted to be deposited within the mixing zone for this model scenario (Table 3-2).

Effect of varying total discharge on predicted-maximum sediment depth. The deposition of drilling mud may impact benthic communities in the vicinity of drilling discharges. The potential impact will depend on the mud characteristics and the depth of the deposited solids (see Section 5.2). Since the total amount of drilling mud produced by each exploratory well will be site specific. The model-predicted mud depth at the edge of the mixing zone was calculated for a range of total discharge scenarios. These scenarios ranged from 10 to 500 percent of the average total drilling mud discharge for a typical well in the Cook Inlet/Shelikof Strait Lease Sale area [i.e., 32,700 to 1,635,000 kg (72,091 to 3,604,558 lb) of drilling muds]. Current speeds of 10 cm/sec (0.33 ft/sec), 20 cm/sec (0.66 ft/sec), or 32 cm/sec (1.05 ft/sec) were used for these scenarios.

The model-predictions shown in Table 3-3 indicate that the mud deposition depths at the edge of the mixing zone may vary from 0.0 to 24 cm (0.0 to 9.4 in) depending on the water depth, current speed, and discharge rate.

3.2 SUMMARY

Computer modeling of drilling discharges and results obtained in other OCS areas support the following conclusions for drilling mud discharges in the Lease Sale area:

- Drilling muds tend to be diluted rapidly following discharge. For a given discharge rate and mud density, the dilution is dependent on the density structure of the water column, the water depth, and current speed. During open-water discharge in water depths ranging from 40 to 120 m (131 to 394 ft), estimated dilutions of dissolved components at the edge of the mixing zone range from 1,285:1 for a current speed of 10 cm/sec to 9,127:1 for a current speed of 32 cm/sec.

TABLE 3-3. ESTIMATED DEPTH OF DRILLING MUDS AT THE EDGE OF THE MIXING ZONE FOR OPEN-WATER DISCHARGE

	Percent of Average Total Discharge							
	10%	25%	50%	100%	200%	300%	400%	500%
	Total Drilling Mud Discharged in Kilograms (pounds)							
Water Depth and Discharge Rate	32,700 (72,091)	81,750 (180,228)	163,500 (360,456)	327,000 (720,911)	654,000 (1,441,823)	981,000 (2,162,734)	1,308,000 (2,883,646)	1,635,000 (3,604,558)
	Mud Depth at Edge of Mixing Zone (cm)							
40 m 1,000 bbl/h (159,091 L/h) 10 cm/sec	0.077	0.19	0.38	0.79	1.54	2.3	3.1	3.8
40 m 1,000 bbl/h (159,091 L/h) 20 cm/sec	0.48	1.2	2.4	4.8	9.6	14.4	19.2	24
70 m 1,000 bbl/h (159,091 L/h) 10 cm/sec	0.003	0.008	0.017	0.034	0.068	0.10	0.14	0.17
120 m 750 bbl/h (159,091 L/h) 10 cm/sec	0.006	0.014	0.028	0.057	0.11	0.17	0.23	0.28
120 m 1,000 bbl/h (159,091 L/h) 20 cm/sec	0	0	0	0	0	0	0	0
120 m 1,000 bbl/h (159,091 L/h) 32 cm/sec	0	0	0	0	0	0	0	0

Note: Shaded areas indicate model scenarios that predict a drilling mud depth of less than 1 cm in areas beyond the 100-m mixing zone boundary.

- Exploratory drilling solids deposition and accumulation is limited to the immediate discharge area. Studies of actual discharges from gravel islands in the Beaufort Lease Sale area (Northern Technical Services 1984; 1985) have shown that the area of significant deposition is generally limited to an area within 500 m (1,650 ft) of the discharge site.

- The general NPDES permit applicable to the Cook Inlet/Shelikof Strait Planning Area does not allow drilling muds to be discharged in water depths exceeding 40 m (131 ft) at a rate less than 1,000 bbl/hour. A discharge rate of 1,000 bbl/hour was incorporated into the OOC model used to assess impacts to the lease sale area; therefore, the model does not permit evaluation of drilling mud discharges to shallow waters (less than 40 m in depth).

4.0 COMPOSITION OF BIOLOGICAL COMMUNITIES

The determination of "unreasonable degradation" of the marine environment is to be based upon consideration of the ten criteria listed in Chapter 1.0. This chapter provides information pertinent to consideration of the two *ocean discharge* criteria shown below:

- **Criteria #3:** "The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain"

- **Criteria #4:** "The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism".

This chapter is intended to provide an overview of the biological communities found within the Cook Inlet/Shelikof Strait Planning Area. This overview will identify key species that are important from an ecological and economical standpoint, or for subsistence harvesting. Significant interspecies relationships, essential environmental requirements, seasonal distribution and abundance, and prominent areas or habitats where these species occur will also be discussed. The biological communities to be discussed in this chapter include the following:

- Plankton (both phytoplankton and zooplankton)

- Benthic Invertebrates

- Fishes

- Marine Birds and Waterfowl

- Marine Mammals.

4.1 PLANKTON

Phytoplankton and zooplankton are vital components of the pelagic plankton community as these two groups provide the food base for many other groups of marine organisms found within Cook Inlet and Shelikof Strait. In addition, larval stages of many benthic and fish species are temporary members of the zooplankton community (meroplankton) during early developmental stages. The distribution, abundance, and seasonal variation of these organisms is strongly influenced by the physical environment.

4.1.1 Phytoplankton

Information on phytoplankton within the lease sale area is based primarily upon data from plankton samples taken within lower Cook Inlet and adjacent bays, as limited information is available regarding phytoplankton from Shelikof Strait. The seasonal cycle of phytoplankton productivity and standing stock in Cook Inlet and Shelikof Strait is typical of northern temperate waters. Both phytoplankton productivity and standing stock increase from April to early July with peaks in May and early July, respectively. Phytoplankton assemblages are dominated by pennate and centric diatoms, with dinoflagellates, microflagellates, and other classes and families of phytoplankton also being present. Phytoplankton biomass is controlled by light, nutrients, and density structure of the water column.

***4.1.1.2 Important Species and Trophic Relationships*.** Diatoms are the most important group of phytoplankton found in high latitude seas (Raymont 1980, p. 242) and dominate the phytoplankton during spring and summer. The most abundant species found in lower Cook Inlet from April to August 1976, were *Thalassiosira* spp., *Melosira sulcata*, and *Chaetoceros* spp. (Larrance et al. 1977). Other important species are listed in Table 4-1. A variety of herbivores in the lease sale area are dependent upon phytoplankton, including zooplankton, benthic invertebrates, and waterfowl.

TABLE 4-1. PHYTOPLANKTON SPECIES PRESENT IN LOWER COOK INLET AT CONCENTRATIONS GREATER THAN 1,000 CELLS/L.

DIATOMS

Actinoptychus undulatus
Bacteriastrum delicatulum
Ceratulina bergonii
Chaetoceros affinis
Chaetoceros cinoresseys
Chaetoceros concavicornis
Chaetoceros constrictus
Chaetoceros convolutus
Chaetoceros debilis
Chaetoceros decipiens
Chaetoceros didymus
Chaetoceros radicans
Chaetoceros secundus
Chaetoceros socialis
Chaetoceros spp.
Corethron hystrix
Cylindrotheca closterium
Denticula semina
Fragilariopsis spp
Leptocylindricus danicus
Melosira sulcata
Navicula distans
Navicula spp.
Nitzschia delicatissima
Nitzschia longissima
Nitzschia spp.
Rhizosolenia delicatula
Rhizosolenia fragillissima
Rhizosolenia stolterfothii
Schroederella delicatula
Skeletonema costatum
Stephenopyxis nipponica
Thalassionema nitzschiodes
Thalassiosira aestivalis
Thalassiosira decipiens
Thalassiosira gravida
Thalassiosira nordenskioldii
Thalassiosira pacifica
Thalassiosira polychorda
Thalassiosira rotula
Thalassiosira spp.
Tropidoneis antarctica

DINOFLAGELLATES

Exuviella spp.
Gymnodinium lohmanni
Oxytoxum spp.
Peridinium miniscululm
Peridinium spp.

CHRYSOPHYTES

Dictyocha fibula
Ebria tripartita

MISCELLANEOUS

green algae
microflagellates

Source: Larrance et al. 1977, pp 36-37.

4.1.1.3 Important Habitats or Areas. Kachemak Bay is the most productive area in lower Cook Inlet. The peak level of primary productivity observed in this area (7.7 g C/m^2/day) is one of the highest values reported from a natural marine environment (SAIC 1977).

4.1.2 Zooplankton

Zooplankton found in the lease sale area include organisms which are planktonic throughout their entire life (holoplankton) and species that are planktonic only during a portion of their lifecycle (meroplankton). The meroplankton consist mainly of the larval stages of benthic invertebrates, which may outnumber the holoplankton for brief periods in shallow water. An abbreviated list of common zooplankton species in Shelikof Strait and Cook Inlet is shown in Table 4-2. More detailed accounts of species found in Shelikof Strait and Cook Inlet are provided by Seifert and Incze (1991) and Damkaer (1977), respectively.

Zooplankton abundance varies seasonally with maximums generally occurring in the summer. A considerable portion of the seasonal biomass variation that occurs in oceanic regions likely reflects the life histories of three large calanoid copepods: *Neocalanus cristatus, Neocalanus plumchrus, and Eucalanus bungii.* These copepods migrate vertically in the water column and various developmental stages occur in the upper 150 m for a minimum of 10 months of the year (Cooney 1987). Smaller copepods, such as *Calanus pacificus* and *Metridia pacificus*, are also abundant at various times of the year. Decapod larvae are present primarily in spring and summer and are more prevalent in bays and nearshore waters (Kendall et al. 1980). Fish eggs and larvae are found throughout the year, although abundance and spatial distribution is highly variable due to seasonal spawning. Euphausiids are most abundant in the summer and display vertical distribution near the surface prior to and during spawning. Seasonal changes in zooplankton distribution are affected by biological factors such as vertical migration and physical factors such as local currents (Alaska Stream and Kenai Current), wind, bathymetry, and fresh water input.

4.1.2.1 Important Species and Trophic Relationships. Copepods are the dominant zooplankton group, both in terms of numbers and biomass (Kendall et al. 1980). Greater than 70% of the oceanic biomass in lower Cook Inlet and upper Shelikof Strait is comprised of three species: *Neocalanus cristatus, Neocalanus plumchrus, and Eucalanus bungii* (Cooney 1987). These species are omnivores, feeding on phytoplankton, zooplankton, and detritus. Chaetognaths are uniformly abundant throughout most of the year whereas cnidaria are most numerous in nearshore and midshelf waters in summer and fall (Kendall

TABLE 4-2. COMMON ZOOPLANKTON AND MICRONEKTON FOR LOWER COOK INLET AND SHELIKOF STRAIT

	Shelikof Strait/Kodiak Island	lower Cook Inlet
Chaetognatha		
Sagitta elegans	X	X
Eukrahnia hamata	X	
Arthropoda		
Copepoda		
Acartia tumida	X	X
Calanus pacificus	X	X
Neocalanus cristatus	X	X
Neocalanus plumchrus	X	
Eucalanus bungii	X	
Metridia pacifica	X	X
Oithona similus	X	X
Pseudocalanus spp.	X	X
Amphipoda		
Parathemisto pacifica	X	
Euphausiacea		
Euphasia pacifica	X	
Thysanoessa inermis	X	X
Chordata		
Oikopleura spp.	X	X

Source: Cooney 1987

TABLE 4-3 ZOOPLANKTON SEASONAL STANDING STOCK IN LOWER COOK INLET AND SHELIKOF STRAIT

	Winter	Spring	Summer	Fall
Shelikof Strait/ (shelf)	42	112	525	77
Kodiak Island (oceanic)	63	70	434	70
lower Cook Inlet	-	5,010	1,440	-

Source: Cooney 1987

et al. 1980). Species within the both of these groups are carnivorous, feeding on zooplankton and small fish. Amphipods are found throughout the year with the greatest abundance in the summer and fall.

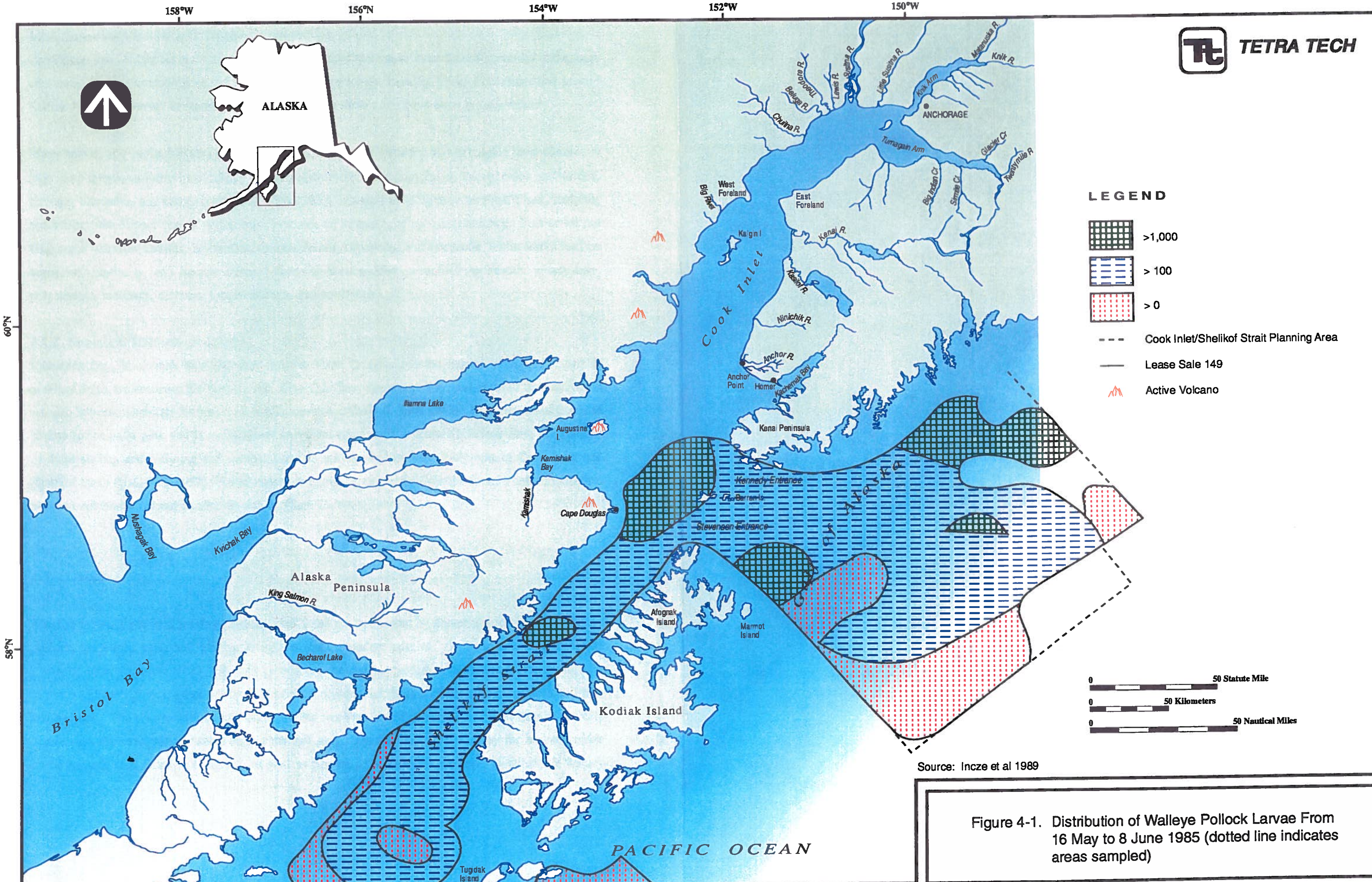
Zooplankton serve as forage for fish (copepod nauplii are critical in the diet of most larval fish), shellfish, and marine birds and mammals. Euphausiids are essential organisms in the diets of yellow Irish lord and yellowfin sole, and mysids are the principal prey of walleye pollock and halibut (SAIC 1979). Copepods and euphausiids are important prey items for minke fin, sei, and humpback whales in lower Cook Inlet.

Important Habitats or Areas. The waters of lower Cook Inlet have a high standing stock of zooplankton in the spring and summer (Table 4-3). In Shelikof Strait, walleye pollock spawn large concentrations of free-floating planktonic eggs near the seafloor during the spring and the resulting larvae have an 8 week planktonic phase (Figure 4-1) (Schumacher and Kendall 1989).

4.2 BENTHIC INVERTEBRATES

Benthic invertebrates are important as prey for higher trophic levels and are important mediators for nutrient recycling. Several benthic species in the lease sale area are harvested commercially: Tanner crab, Dungeness crab, weathervane scallop, and shrimps. Razor clams are harvested from nearshore areas and bays. Benthic species frequently harvested for subsistence purposes include the following: clams (razor, butter, steamer), crabs (Tanner, Dungeness, red king), cockles, and shrimp.

From 1976-1978, studies were conducted by Feder (1981) on the distribution of benthic species in lower Cook Inlet. Approximately 165 epifaunal species and 264 infaunal species were collected in this study. Arthropods, molluscs, and echinoderms were the most frequent epifaunal species accounting for 60, 59, and 23 of the total species respectively, as well as dominating the total biomass. Molluscs, arthropods, and echinoderms were the most frequent infaunal species accounting for 128, 54, and 26 of the total species respectively (Feder 1981). Additional discussion of benthic epifaunal and infaunal species in lower Cook Inlet and Shelikof Strait including distribution and abundance may be found in the ODCE for Sale 60 (U.S. EPA 1983, Section 5) and the ODCE for Sale 88 (U.S. EPA 1984, Appendix C).



Source: Incze et al 1989

Figure 4-1. Distribution of Walleye Pollock Larvae From 16 May to 8 June 1985 (dotted line indicates areas sampled)

4.2.1 Important Species and Trophic Relationships

The Tanner and Dungeness crabs are the principal commercial benthic invertebrates harvested in the lease sale area. Large populations of red king crab were previously found in lower Cook Inlet and around Kodiak Island, however, in recent years the numbers in these areas have been greatly reduced.

Many benthic species in the lease sale area are important prey items for higher trophic level consumers [e.g., amphipods, molluscs (particularly *Spisula polynyma* and *Nuculana fossa*), Tanner crabs, ophiuroids, shrimps, barnacles, and hermit crabs (U.S. EPA 1983)]. As well as being prey for Pacific cod, sculpins, and halibut, the Tanner crab is also a major predator on infaunal and epifaunal benthos. Post-larval red king crabs consume detritus, bryozoans, foraminiferans, copepods, and ostracods, while adults feed on barnacles, molluscs, and hermit crabs. Pandalid shrimp feed primarily on benthic crustaceans, polychaetes, molluscs, diatoms, foraminiferans, and small fish.

4.2.2 Important Habitats or Areas

Kamishak Bay, Kachemak Bay, the area between Cape Douglas and the Barren Islands, and part of Shelikof Strait are nurseries for Tanner crab. Kamishak Bay, Kachemak Bay, and areas of Shelikof Strait are also important habitats for king crab and Dungeness crab (U.S. EPA 1983). Five species of pandalid shrimp (principally pink and humpback) are harvested commercially from Kachemak Bay. Populations of these shrimp are declining and current harvests are allowed over limited areas in Cook Inlet and Shelikof Strait (U.S. DOI 1992). Razor clams are harvested primarily from the Kenai Peninsula beaches between Anchor Point and Kasilof as well as Clam Gulch.

4.3 FISHES

The fish assemblages in Cook Inlet and Shelikof Strait are dominated by demersal species, with walleye pollock, yellowfin sole, and halibut being the most abundant species. Anadromous fish including chinook, coho, sockeye, chum, and pink salmon are the most important commercial fish in Cook Inlet in terms of harvest volume and value. Other fish of commercial value include: walleye pollock, halibut, and herring. The five species of salmon and other anadromous fish such as steelhead trout and Dolly Varden are the most popular sport fish in the sale area. Species important as prey for higher trophic levels include sand lance and capelin, as well as previously mentioned species. Detailed life history information and distribution of the species discussed below can be found in the "Atlas to the Catalog of Waters Important to Spawning, Rearing, and Migration of Anadromous Fish" and "Alaska Habitat Management Guides" published by the Alaska Department of Fish and Game.

4.3.1 Important Species and Trophic Relationships

The following discussion will be divided into commercially harvested fish, such as Pacific salmon and halibut, and other species which are not commercially harvested, but are important as prey for higher trophic levels, such as sand lance and capelin.

4.3.1.1 Commercially Harvested Fish. Five anadromous species, two groundfish species, and one pelagic species constitute the bulk of the fish harvested commercially in the lease sale area. A brief description of each of these species is provided below.

Pink salmon. Pink salmon spawn annually with substantially larger returns in even-numbered years. The spawners migrate to their natal streams in early summer and runs may continue into early August. The fry emerge from the stream gravel in spring and school in estuarine waters for approximately a month before beginning a gradual, irregular movement to the ocean where they usually remain for two years. In late summer and early fall, the large schools move offshore to deeper waters, while still remaining relatively close to shore until December when they move further offshore. Pink salmon is the most abundant salmon species in lower Cook Inlet (KPB 1990). Copepods, amphipods, tunicates, and euphausiids are the dominate prey of pink salmon.

Sockeye salmon. Sockeye salmon spend two to three years in the ocean before migrating to their natal streams to spawn from early June until late August. Young sockeye remain in coastal waters during their first year of life. Juveniles feed on copepods, fish eggs and larvae, and shrimp larvae. Sockeye salmon prey consists of copepods, amphipods, tunicates, and euphausiids.

Chum salmon. Chum salmon remain in the ocean for two to four years before migrating to their natal streams. They spawn from late July to late October and are the second most abundant species along the shoreline in lower Cook Inlet from May to September (KPB 1990). The fry spend several months in estuarine waters before beginning their offshore migration in early fall. Juveniles feed on zooplankton (primarily copepods) and aquatic insects; adults feed on zooplankton, small fish, and squid (U.S. DOI 1984).

Coho salmon. Coho salmon spend one to two years in the ocean before migrating to their natal streams from late July to December. The majority of coho in the lease sale area spawn in upper and central Cook Inlet. Young coho enter the ocean after one to four winters in freshwater and remain nearshore and near the surface where they feed on small fish and zooplankton crustaceans before moving further offshore (U.S. EPA 1983). Adult coho feed on squid, euphausiids, and small fish in the open ocean.

Chinook salmon. Chinook salmon spawn from mid-May to early August. Young chinook enter the ocean after spending one to two years in freshwater and remain nearshore for a short period before moving further offshore. Juvenile chinook feed primarily on fish larvae and aquatic insects whereas adults feed on herring, sand lance, squid, and crustaceans.

Walleye pollock. Walleye pollock is the dominant groundfish commercially harvested in lower Cook Inlet and Shelikof Strait. This demersal species is found in large schools. Annual spawning begins in early spring and may continue into early summer. The larvae form dense aggregations that appear to be strongly dependent on ocean dynamics (e.g., the Alaska Coastal Current) for transport (Schumacher and Kendall 1989). Pollock migrate seasonally, moving from deeper waters in the winter to more shallow water in the summer. The fish also undergo diurnal, vertical migrations from deeper to shallow waters in the evenings (U.S. DOI 1984). Pollock feed on numerous species including mysids, euphausiids, and small fish. In addition to being of great commercial value, pollock serves as food for other marine fishes, birds, and mammals.

Pacific halibut. Pacific halibut is the largest and most commercially valuable of the flounders. Halibut are slow growing and may live longer than 30 years. They spawn in deep waters where the larvae remain 4 to 5 months before entering the benthos. Adults feed on fishes, crabs, clams, squids, and other invertebrates. Larval halibut consume a wide variety of pelagic organisms including crustaceans, euphausiids, and amphipods. Halibut annually move to and from deeper waters but do not display obvious migratory patterns. Alaska populations of halibut are currently high, but are starting to decline (U.S. DOI 1992).

Pacific herring. Herring sac-roe is of high commercial value while adult herring are currently used mainly for bait in other fisheries. The Pacific herring populations in Alaska are generally on a downward trend. Pacific herring undergo annual spring migrations from pelagic waters to the coastal areas of lower Cook Inlet to spawn. The eggs are deposited on kelp, other seaweeds, rock substrate, and detritus in the shallower coastal zone. After spawning and hatching, both adult and larval herring remain in nearshore water until fall when the schools move to deeper and warmer waters to overwinter. Adults and larvae feed primarily on zooplankton (U.S. DOI 1992). Larvae and juveniles feed and grow in estuaries and embayments, thus making them vulnerable to changes in inshore habitats. Herring are important food fishes for other pelagic fishes, and marine birds and mammals. They are also important target species in the diets of communities participating in subsistence fishing.

4.3.1.2 Non-commercially Harvested Species. There are three species of fish in the lease sale area that are important as prey species for higher trophic levels: Pacific sand lance, capelin, and yellowfin sole. Dolly Varden is an important sportfish species recreationally harvested in Cook Inlet. A brief description of each of these species is provided below.

Pacific sand lance. Pacific sand lance are abundant in nearshore areas and bays throughout lower Cook Inlet and generally inhabit water less than 100 meters deep. Sand lance lack a swim bladder and must actively swim, rest on the seafloor, or bury themselves in sand or fine gravel. They may form large pelagic schools during the day and return to the bottom at night. Sand lance spawn during winter in areas of strong current. The larvae are planktonic and feed on diatoms, copepods, shrimp, and barnacle nauplii (Blackburn 1979). Pacific sand lance are prey items for salmon, Pacific cod, halibut, other demersal fishes, marine birds and mammals.

Capelin. Capelin generally form large schools near the bottom and large concentrations may occur within the lease sale area. Spawning usually occurs from the end of May to about mid-July. Eggs are deposited on sandy beaches at night or on cloudy days following a high tide and are buried in the sand by wave action. Capelin consume copepods, amphipods, euphausiids, and shrimp and are important prey items for other fishes, marine birds and mammals (U.S. EPA 1983).

Yellowfin sole. Yellowfin sole are the second most abundant offshore demersal fish species found in lower Cook Inlet. This population of yellowfin sole is the largest reproducing population east of the Bering Sea (Blackburn 1979). Prey items include juvenile fishes, amphipods, euphausiids, and polychaetes.

Dolly Varden. Dolly Varden spawn mostly in the fall, with the majority of the spawners located in the Anchor River in mid-October. The eggs incubate over winter, generally four to five months. Many anadromous Dolly Varden are capable of repeated spawning, although they suffer a high post-spawning mortality and generally do not spawn in consecutive years.

4.3.2 Important Habitats or Areas

The nearshore areas of Cook Inlet, particularly Kachemak and Kamishak Bays, and other small inlets and bays, are important habitat for juvenile herring, salmon, Dolly Varden, capelin, rockfish, and sand lance (Blackburn 1979).

The distribution of the five salmon species differs between upper Cook Inlet (north of Anchor Point) and lower Cook Inlet (from Cape Douglas to Cape Fairfield). In upper Cook Inlet, sockeye is the most abundant salmonid, followed by pink, chum, coho, and chinook, respectively. In lower Cook Inlet, pink salmon is the most abundant salmonid, followed by chum, sockeye, coho, and chinook, respectively. The Kenai and Kasilof Rivers, which discharge into upper Cook Inlet, are major sockeye, pink, coho, and chinook salmon-producing streams. The Big Kamishak, Little Kamishak, and McNeil Rivers, which discharge into Kamishak Bay in lower Cook Inlet, are the major chum salmon-producing streams. Adult salmon are present in nearshore waters and estuarine waters adjacent to the Kenai Peninsula from late April to early November (KPB 1990). Salmon are generally found in the upper 10 m of the water column.

Pacific herring are abundant throughout the coastal waters of Cook Inlet and Shelikof Strait. Herring utilize the intertidal and subtidal zones in coastal areas to spawn (McGurk 1989).

Walleye pollock produce free-floating planktonic eggs in winter and spring with large concentrations found in Shelikof Strait (Figure 4-1). The larvae appear to be strongly influenced by upper-ocean dynamics (Schumacher and Kendall 1989). Pollock migrate seasonally, moving from deeper waters in the winter to more shallow water in the summer. The fish also undergo diurnal vertical migration from deeper to shallower waters in the evening (U.S. DOI 1984).

Large concentrations of yellowfin sole are located southeast of Augustine Island and in Kamishak Bay. Seasonal migrations may occur from Kamishak Bay to offshore waters during the winter. Juvenile yellowfin sole typically inhabit the nearshore environment.

4.4 MARINE BIRDS AND WATERFOWL

Marine birds and waterfowl are significant components of the marine ecosystems in Cook Inlet and Shelikof Strait waters. Over 100 species of marine and coastal birds with populations numbering several million occur in the lease sale area (scientific names of species discussed in this chapter are provided in Appendix B). More than 60 seabird colonies are located in the lower Cook Inlet region and approximately 120 bird colonies have been identified in the Shelikof Strait region (U.S. DOI 1983).

The Arctic peregrine falcon and the American peregrine falcon may occasionally be found in the lease sale area and are listed as threatened and endangered, respectively, according to the Endangered Species Act. The Steller's eider is listed as a candidate species.

4.4.1 Important Species and Trophic Relationships

The following discussion will be divided into marine birds, which spend at least a portion of their lives in the open ocean, and waterfowl, which are not typically found far from land.

4.4.1.1 Marine Birds. Fifteen species of marine birds constitute 90 percent of the total seabird population in the Gulf of Alaska. Six of these species have populations over one million (fork-tailed storm petrel, tufted puffin, Leach's storm petrel, common murre, black-legged kittiwake, and horned puffin) (Baird and Gould 1983). Other common seabirds in the lease sale area include shearwaters, fulmars, cormorants, gulls, terns, guillemots, murrelets, and auklets. Many birds such as shearwaters rarely come to land except to breed and others such as arctic terns and mew gulls may breed hundreds of miles inland. Most seabirds return to breeding colonies in April and lay eggs in May, June, and July. While seabirds are rearing young, foraging is limited to nearshore waters. Most seabirds leave their breeding colonies by October.

Hundreds of thousands of shorebirds use the coastal areas for feeding and resting as they migrate to breeding grounds in western and northwestern Alaska every year. These birds use gravel beaches, rocky shores, and intertidal mud flats as forage areas for clams and small invertebrates. The total world population of the Western sandpiper, most of the world population of surfbird and black turnstones, large numbers of dunlin, and short-billed dowitcher migrate along the coast of southcentral Alaska. The most common shorebirds found in the coastal habitats adjacent to the lease sale area include; sandpipers, plovers, surfbirds, turnstones, whimbrels, dowitchers, dunlins, godwits, oystercatchers, and phalaropes.

Seabirds feed primarily on marine invertebrates and fishes, although their diet varies according to body and bill size, age, season, prey size and availability. The major food source during spring and summer months include capelin, sand lance, euphausiids, squid, and pollock. Various benthic invertebrates and demersal fish are the main winter food sources (U.S.DOI 1983). Studies that have measured the food fed to seabird chicks have indicated that capelin and sand lance comprise 48-84% of their diets (Baird and Gould 1983). Most foraging of breeding birds occurs within 30 miles of their colony and usually within three miles of land.

A brief description of fourteen seabird species commonly found in the lease sale area is provided below.

Storm-petrels. There is a large breeding population of approximately 150,000 fork-tailed storm petrels in the Barren Islands (Hatch 1983). Leach's storm petrel also occur in the Barren Islands. This species feeds in oceanic waters beyond the continental shelf, while fork-tailed petrels make more intensive use of shelf and nearshore waters. Storm-petrels feed on copepods, amphipods, euphausiids, and fish.

Puffins. Horned and tufted puffins have breeding colonies located in Cook Inlet, the Barren Islands, along Kodiak Island, and along the eastern side of the Alaska Peninsula. Tufted puffins are the most common breeding birds in many areas such as Kodiak and the Barren Islands. Horned puffins lay their eggs in June, while tufted puffins lay eggs from May to June. Puffins feed their chicks fish (primarily capelin and sand lance) whereas adults consume a more varied diet which includes molluscs, crustaceans, and polychaetes (Peterson 1983a).

Murres. Common and thick-billed murres have breeding colonies in Cook Inlet, the Barren Islands, and along the eastern side of the Alaska Peninsula. Common murres are the more abundant of the two species. The thick-billed murre occurs in large numbers only on the Semidi Islands. Murres typically lay their eggs from June to July (Peterson 1983b).

Black-legged kittiwake. The black-legged kittiwake has breeding colonies in Cook Inlet, the Barren Islands, Kodiak Island, and along the eastern side of the Alaska Peninsula. Colonies range in size from a few pairs to more than 100,000 birds, particularly in the Semidi Islands. Colonies of kittiwakes are essentially permanent, although small colonies in sub-optimal habitat may be temporary. Typical egg production is from June to July (Nysewander 1983a).

Shearwaters. Sooty and short-tailed shearwaters are the most abundant seabirds over the Kodiak shelf from May to September. Shearwaters are pursuit diving birds and can dive to a minimum depth of at least 5 meters. Sooty shearwaters feed primarily upon capelin, sand lance, and cephalopods. Short-tailed shearwaters feed primarily upon euphausiids, capelin, and cephalopods (Krasnow and Sanger 1982).

Cormorants. In open water cormorants feed on dense schools of small fish like smelt and anchovies and on bottom-dwelling coarse fish. Cormorants forage almost entirely in nearshore waters. The double-crested, pelagic, and red-faced cormorants all have breeding colonies within the vicinity of the lease sale area (Nysewander 1983b).

Glaucous winged-gull. Glaucous-winged gulls are the most common coastal gull in Alaska. There are many breeding colonies along Kodiak Island and the eastern shores of the Alaska Peninsula as well as the Kenai Peninsula. Most colonies of these gulls are small, less than 1,000 birds. They feed primarily on fish and invertebrates. Capelin, sand lance and herring are the most important prey items (Baird 1983).

Northern fulmar. The northern fulmar is among the most common pelagic bird in Alaska. One third of the Alaskan fulmar population is reared on the Semidi Islands, which are assumed to be of major importance to the maintenance of this species. Fulmars feed on a variety of prey items including squid, crustaceans, chaetognaths, pelagic polychaetes, and are one of the few marine birds known to feed on hydrozoans and ctenophores (Hatch 1983b).

4.4.1.2 Waterfowl. Waterfowl in the lease sale area include ducks and geese. During the fall migration, the numbers of ducks in saltwater marshes and tideflats of Cook Inlet increase dramatically as local populations are supplemented by ducks from the north and west. Dabbling ducks (mainly American widgeon, mallard, northern pintail, and green-winged teal) comprise approximately 60 percent of the breeding waterfowl in Trading Bay, Redoubt Bay, and the Fox River Flats (KPB 1990). The initial nesting period for dabbling ducks usually begins in mid-April and extends through June. The molt and brood-rearing period occurring from late June to early August is a stressful period and demands considerable energy. Consequently, waterfowl are sensitive and vulnerable during this time. In Cook Inlet, dabbling ducks have two population peaks in the fall. The first is in mid to late August and the second is late September to early October. By November, most dabbling ducks have departed Cook Inlet for wintering grounds. Dabbling ducks feed primarily on invertebrates and plant matter.

Most diving ducks arrive on their breeding grounds by late May, with the nesting period generally extending through June. Brood rearing and molting occurs throughout July and August. The majority of the diving ducks that breed in Alaska are residents of Alaskan coastal areas in winter. Diving ducks are the most sensitive birds to oil spills as they inhabit nearshore marine and estuarine waters most of the year and due to their feeding habits and methods.

Ducks. The most abundant species of diving ducks in Cook Inlet include the greater scaup, common goldeneye, Barrow's goldeneye, oldsquaw, white-winged scoter, surf scoter, and black scoter. Less common species include canvasback, common merganser, red-breasted merganser, bufflehead, and harlequin duck. Diving ducks feed primarily on crustaceans, molluscs, insects, and fish. Many diving ducks overwinter in Cook Inlet, particularly Kachemak Bay.

Geese. The most common geese in Cook Inlet are the Canada goose, tule white-fronted goose, and during migration, the lesser snow goose and greater white-fronted goose (U.S. DOI 1992).

Steller's Eider. The Steller's eider is listed as a candidate species receiving Category-1 status pursuant to the Endangered Species Act. Due to higher priority species awaiting listing action, this species was listed as a candidate species rather than a threatened species until further notice. The Steller's eider population in the Alaska Peninsula may have declined as much as 50-75 percent in the last twenty-five years to less than 65,000 birds as of 1983. The causes for this decline are not known at this time (U.S. Fish and Wildlife Service 1992).

Steller's eiders nest in coastal tundra areas and west of the Colville River to Barrow, Alaska. This region is the only remaining area in North America where these birds are known to breed. After breeding, this species migrates south to molt along the Alaskan coast, particularly at Izembek and Nelson Lagoons. The majority of the world population of Steller's eiders winters along the Alaska Peninsula from the eastern Aleutian Islands to Kodiak Island. They remain in nearshore marine habitats for most of the year feeding upon crustaceans and molluscs (U.S. EPA 1993, p.78; U.S. Fish and Wildlife Service 1992).

4.4.2 Important Habitats or Areas

The following discussion will be divided into marine birds and waterfowl.

4.4.2.1 Marine Birds. Many seabirds winter in offshore waters while others remain in Alaskan nearshore waters, particularly Kachemak Bay. In Cook Inlet, Shelikof Strait, and the Barren Islands, there are over one million nesting seabirds with the largest aggregation found in the Barren Islands (Figure 4-2) (U.S.DOI 1984).

There are a limited number of mudflats in the migratory flyway between the Washington coast and the Alaska Peninsula. Critical habitat for migrating shorebirds in the vicinity of the lease sale area include the Fox River Flats, Mud Bay, and Kamishak Bay. A breeding colony of the rare Aleutian terns and more common Arctic terns nest along the mud flats in the Homer area.

Afognak Strait (located at the north end of Kodiak Island), Kodiak Island, and Kachemak Bay are important winter congregation areas for murres and auklets in particular, as well as other species. There are four species of loon and several grebe species that overwinter in lower Cook Inlet, particularly Kachemak Bay.

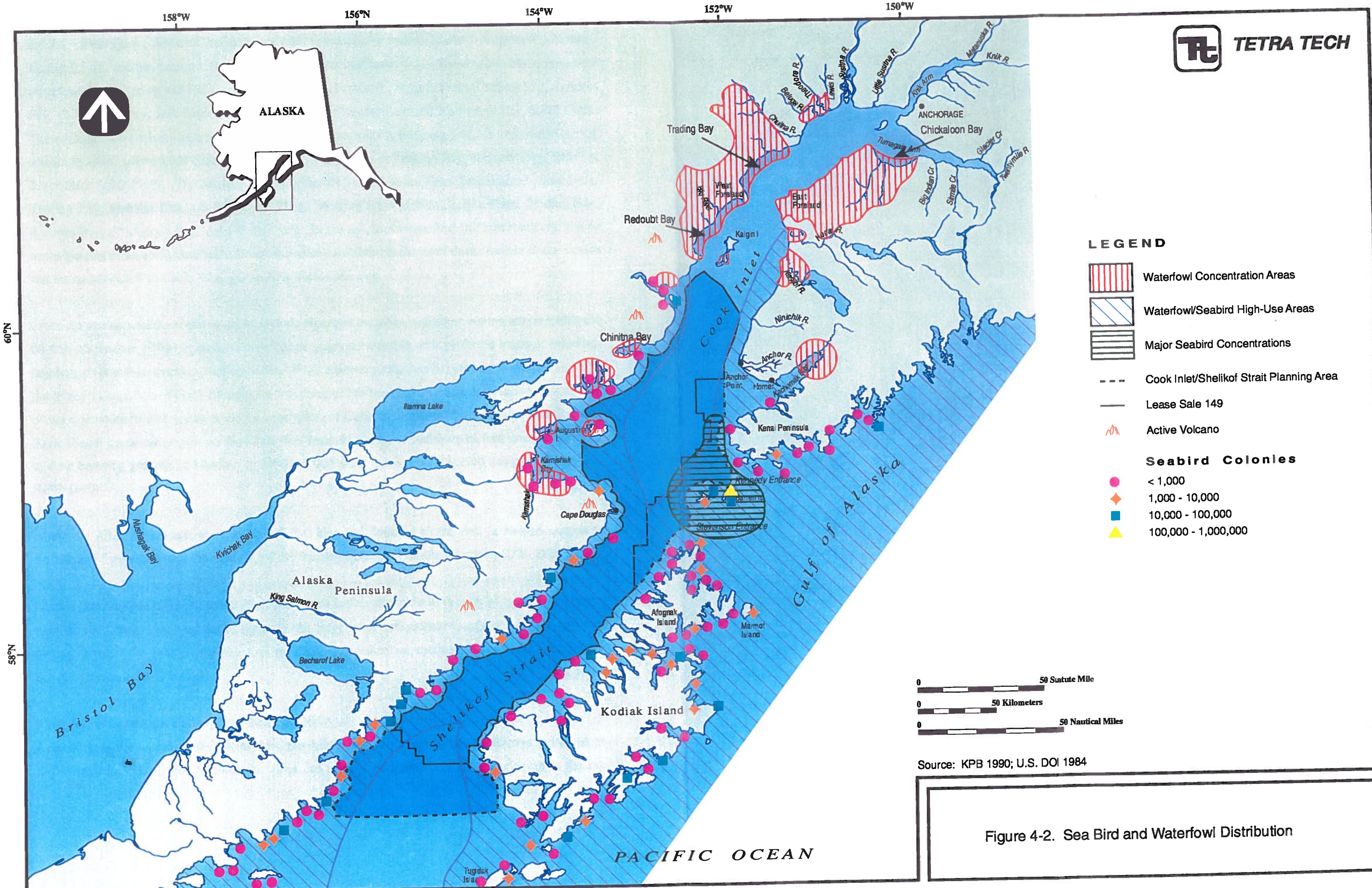


Figure 4-2. Sea Bird and Waterfowl Distribution

4.4.2.2 ***Waterfowl.*** Areas of major importance to waterfowl include lower and upper Cook Inlet, Kodiak Island, and the eastern side of the Alaska Peninsula (Figure 4-2). The largest concentrations of waterfowl during spring and fall are found in the Kenai Lowlands, Susitna Flats, Trading Bay, Redoubt Bay, Chickaloon Bay, Fox River Flats, Tuxedni Bay, Chinitna Bay, and Kachemak Bay (KPB 1990). These locations are areas where waterfowl rest and feed en route to breeding grounds and overwintering areas. In 1984, over 30,000 breeding waterfowl were present at Trading Bay, Redoubt Bay, and Fox River Flats (KPB 1990). The primary nesting areas are located in the Kenai Lowlands, Susitna Flats, Trading Bay, Redoubt Bay, and Fox River Flats. Molting areas include Susitna Flats, Trading Bay, Redoubt Bay, Chickaloon Bay, and Chinitna Bay. In the fall, most waterfowl migrate south and east to overwintering areas along the Pacific Coast, however substantial numbers of ducks remain in the marine and estuarine waters of Cook Inlet, particularly Kachemak Bay.

Preferred marine habitats of diving ducks include protected estuaries, and other marine waters within the 60 ft depth contour. The largest concentrations of geese are found in their preferred habitats; estuaries, lagoons, river deltas, marshes, and tidelands. High concentrations occur on the tidal salt marshes and the extensive mud flats of Cook Inlet during the spring and fall migrations. The only known nesting area of the tule white-fronted goose is on the west shore of Cook Inlet, primarily in Trading and Redoubt Bays. Snow geese congregate on the Kenai flats from mid-April to mid-May to feed and rest en route to their breeding grounds in Siberia. In 1988, 25,000 snow geese were observed using the Kenai flats (KPB 1990).

Along the Alaska Peninsula, as many as 100,000 king and Steller's eiders molt in Nelson Lagoon in August and September with the majority of the females molting in Izembek Lagoon (U.S. DOI 1992).

Canada geese nest on lakes and ponds, marshes. Nests are usually initiated in early May, dependent upon weather conditions. Molting flocks typically use large lakes and protected coastal waters away from nesting areas. On coastal marshes and tideflats, geese feed on molluscs, crustaceans, and other invertebrates as well as plants.

4.4.3 Threatened and Endangered Bird Species

According to the Endangered Species Act, the Arctic and American peregrine falcons are listed as threatened and endangered, respectively. The use of organochlorine pesticides beginning in the late

1940's greatly affected these falcons. In 1978, six years after the US restricted the use of these pesticides, the peregrine population began to increase, and the trend has continued to the present. Based upon 1991 surveys, the Arctic peregrine falcon population now stands at approximately 160 pairs and the Alaskan population of American peregrine falcons is estimated to be 225 pairs (U.S. DOI 1992). As a result, the status of this species is currently being reviewed and may lead to a reclassification proposal for peregrines. The American Peregrine Falcon Recovery Team determined that some scattered nesting of the American peregrine falcon may be present adjacent to the lease sale area in 1982. It was also determined that migration and wintering of Arctic and/or American peregrine falcons may occur as well (U.S. DOI 1984). Thus, it is assumed that migrating Arctic and American peregrine falcons probably occur sporadically in the Cook Inlet/Shelikof Strait Planning Area during migration (U.S. DOI 1992).

4.5 MARINE MAMMALS

Twenty-one species of marine mammals [seventeen species of cetaceans, three species of pinnipeds, and one mustelid (the sea otter)] are found year round in Cook Inlet and/or Shelikof Strait, or use these areas as potential migratory routes. All marine mammals are protected under the Marine Mammal Protection Act (MMPA) of 1972. The MMPA also incorporates regulations and restrictions regarding the harvests of marine mammals. Additional protection is provided for gray, sei, fin, blue, right, humpback, and sperm whales under the Endangered Species Act of 1973 (ESA). Additional regulations associated with the northern fur seal are provided by a 1957 treaty, the Interim Convention on Conservation of Northern Fur Seals.

Marine mammals in the Gulf of Alaska are important constituents of the Alaskan food web, annually consuming 7.55 x 10^6 metric tons of euphausiids, copepods, fish, cephalopods, and crustaceans (Calkins 1987). The most frequent prey for marine mammals in this region are; copepods, euphausiids, herring, cod, walleye pollock, capelin, salmon, cephalopods, and crustaceans. Fin and Sei whales have the highest annual consumption rates followed by the Dall porpoise and Steller sea lion (northern sea lion).

4.5.1 Important Species and Trophic Relationships

The following discussion will be divided into pinnipeds (seals and sea lions), sea otters, and cetaceans (whales).

4.5.1.1 Pinnipeds. Three pinniped species are found in the lease sale area. The Steller sea lion and harbor seal occur frequently, while the northern fur seal is an occasional seasonal migrant to the area.

Steller sea lion. The Steller sea lion population is located from the Aleutian Islands to the Kenai Peninsula (Figure 4-3). The breeding rookeries at Marmot and Sugarloaf Islands contribute close to half of the entire sea lion productivity in the Gulf of Alaska (U.S. DOI 1983). The most frequently consumed prey in the Kodiak area is walleye pollock (42 percent), octopus (26 percent), and flatfish (25 percent)(Calkins and Goodwin 1988).

Harbor seal. The harbor seal has an extensive range extending from the Bering Sea southward to Baja California. Recent surveys of harbor seals suggest that there has been a 75 percent decline in harbor seal abundance over the past six years at Tugidak Island, the westernmost of the Trinity Islands. This location formerly held one of the world's largest concentrations of harbor seals (U.S. DOI 1992). The reason for this decline is not known at this time.

Harbor seals tend to frequent nearshore waters and haul out on offshore rocks, sandbars, and beaches of remote islands. These seals often move considerable distances between various haul out sites, although they tend to have a limited number of preferred sites which they return to repeatedly. The breeding and pupping season occurs from late May through July (KPB 1990). The diet of harbor seals is highly varied with prey primarily consisting of herring, eulachon, walleye pollock, octopus, salmon, shrimp, and flounder.

Northern fur seal. The northern fur seal has a range extending from the Bering Sea south to San Diego, California. The bulk of the fur seal population migrate east of Kodiak Island and the Kenai Peninsula although a very small portion of this population seasonally occurs in Shelikof Strait (U.S. DOI 1983). This seal does not typically occur in Cook Inlet or Shelikof Strait and there are no breeding areas within or adjacent to the lease sale area (Loughlin 1989). These seals are migratory and widely dispersed throughout this range during the non-breeding season (November to May) in pelagic waters. During other times of the year, the majority of the entire population is concentrated in the Pribilof Islands. While most fur seals migrate southward from Alaskan waters, a portion of the population, principally young non-breeding males, remain in the Gulf of Alaska year-round.

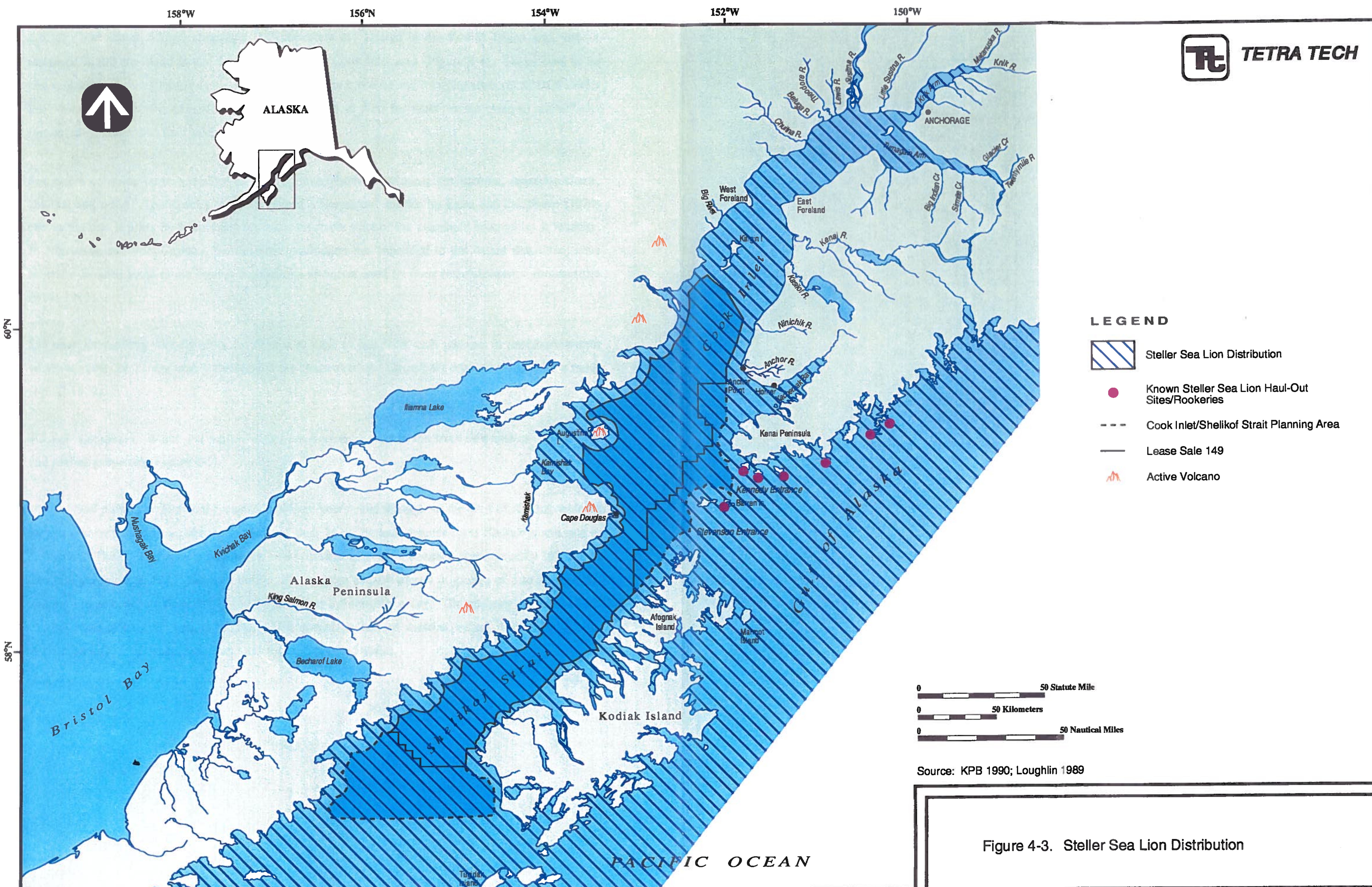


Figure 4-3. Steller Sea Lion Distribution

4.5.1.2 Sea Otters. Approximately 6,000 sea otters are located in the Kodiak Island area and an estimated 3,500 are found in the Kenai Peninsula and Cook Inlet area (Figure 4-4). Otters tend to be non-migratory, moving relatively short distances between breeding and foraging areas (U.S. DOI 1992). Sea otters are extremely susceptible to marine pollution as their fur must remain clean to maintain its insulative qualities, and they seldom leave the water.

Sea otters consume large quantities of benthic invertebrates, including sea urchins, mussels, clams, chitons, and crabs. This species has been termed a "keystone" species by Estes and Palmisano (1974) due to the role it plays in determining the ultimate stable state of the nearshore community it inhabits. In Nanwalek and Port Graham, the sea otter population has expanded to the extent that otters have severely depleted some of the benthic invertebrate resources used by these two subsistence communities (KPB 1990).

Sea otter interactions with fisheries are limited to theft of bait from crab pots set in nearshore waters where commercial Tanner crab activities and sea otters overlap. Occasional drowning occurs as a result (MMC 1989).

4.5.1.3 Cetaceans. Killer and minke whales are frequently seen in the lease sale area as well as Dall and harbor porpoises (Figure 4-5).

Dall porpoise. The Dall porpoise is present year-round throughout the Gulf of Alaska, with the largest numbers occurring over the continental shelf in spring and summer from Kodiak Island east to Icy Strait. The Gulf of Alaska population was estimated to contain between approximately 152,280 to 246,900 porpoises in 1983 (Bouchet 1983). This species usually travels in groups of 2 to 20 animals, although large concentrations of over 1,000 porpoises infrequently occur. The majority of breeding and calving takes place from June to August. Dall porpoises feed on walleye pollock, sablefish, capelin, Pacific herring, sand lance, eulachon, and squid (Crawford 1981).

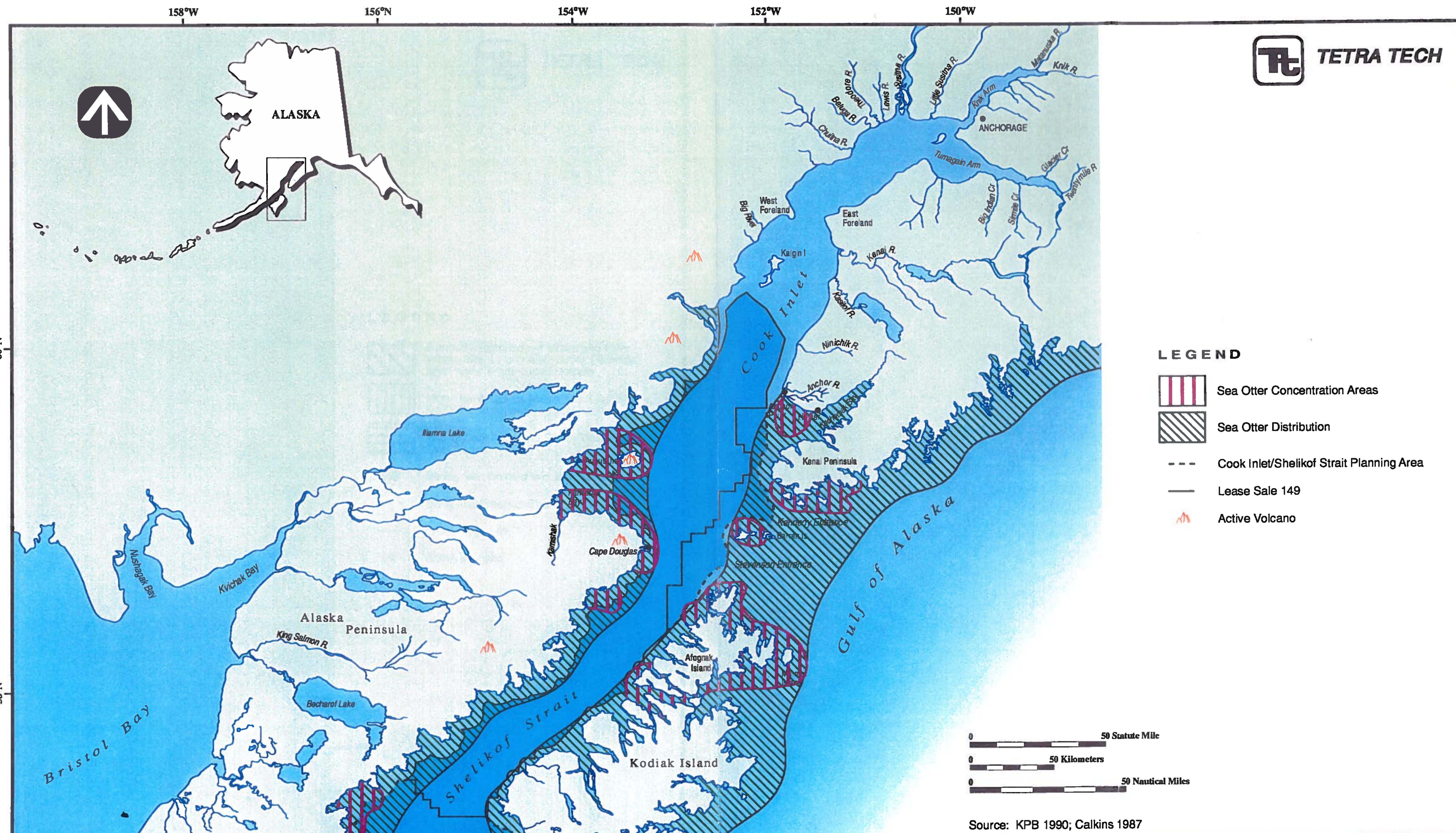


Figure 4-4. Sea Otter Distribution.

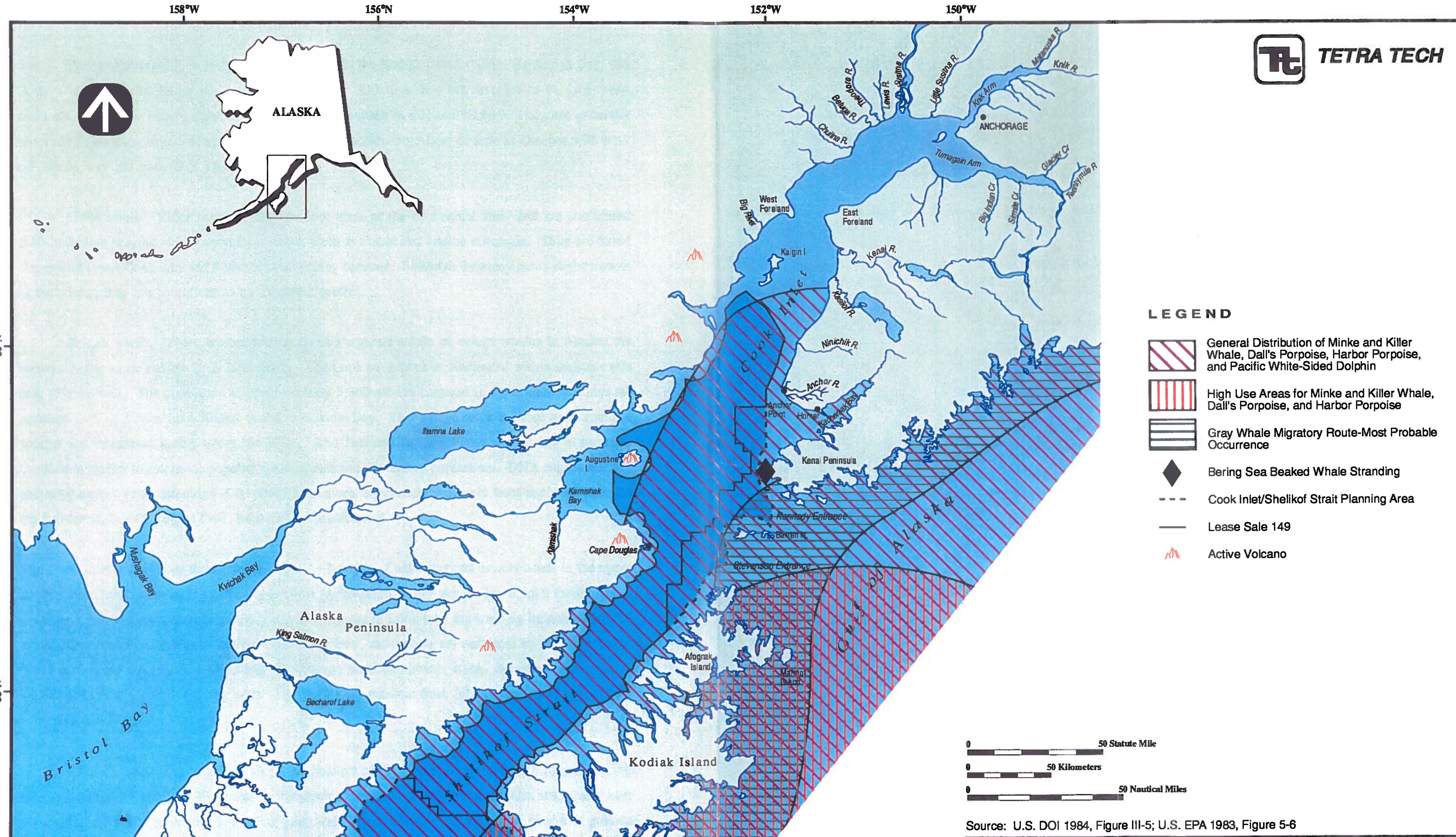


Figure 4-5. Cetacean Distribution

Harbor porpoise. The harbor porpoise occurs in the Kodiak Island region, Kachemak Bay, and in the Gulf of Alaska during the spring and summer. Although they are assumed to be year-round residents where they occur, sightings are much less frequent in fall and winter. They are generally observed in harbors, bays, and river mouths. Breeding occurs from June or July to October with peak calving in May and June (U.S. DOI 1984).

Killer whale. Killer whales prefer shallow areas of the continental shelf and are considered surface feeders preying mostly upon large fishes when available and marine mammals. They are found throughout lower Cook Inlet and Shelikof Strait during summer. Although they may move slightly south in the winter, they are considered to be a resident species.

Beluga whale. There are believed to be two separate stocks of beluga whales in Alaska: the western Arctic stock and the Cook Inlet stock. The Cook Inlet stock is distributed within the lease sale area (Figure 4-6). The population of approximately 1,300 whales centered in Cook Inlet occupies the northern Gulf of Alaska from Kodiak Island to Yakutat Bay. This beluga stock is listed as a candidate species for threatened listing under the ESA. The National Marine Fisheries Service is currently conducting studies to determine population abundance and life history parameters. DNA studies are also currently underway to determine if the Cook Inlet stock is genetically distinct from the western arctic stock (Morris, R., 16 August 1993, personal communication).

The Cook Inlet area is used throughout the year by belugas. Concentrations usually occur in the upper northwestern inlet in the spring and early summer (April-June). They use the lower inlet more often in the winter. Movement and seasonal distribution of belugas in Cook Inlet are strongly influenced by fish availability, especially smelt and salmon smolt. In winter, movements are restricted by the combination of ice and spring tides (U.S. DOI 1984). The beluga feeds on salmon, smelt, flounder, sole, sculpin, cephalopods, and shrimp. Calving takes place during the summer from July to August (Calkins 1989, U.S. DOI 1992).

Minke whale. The minke whale is the smallest of the baleen whales. It is a coastal species, usually occurring within the 200 meter depth contour. In spring, most minke whales are located over the continental shelf, especially in shallow nearshore waters. During summer, the season of greatest

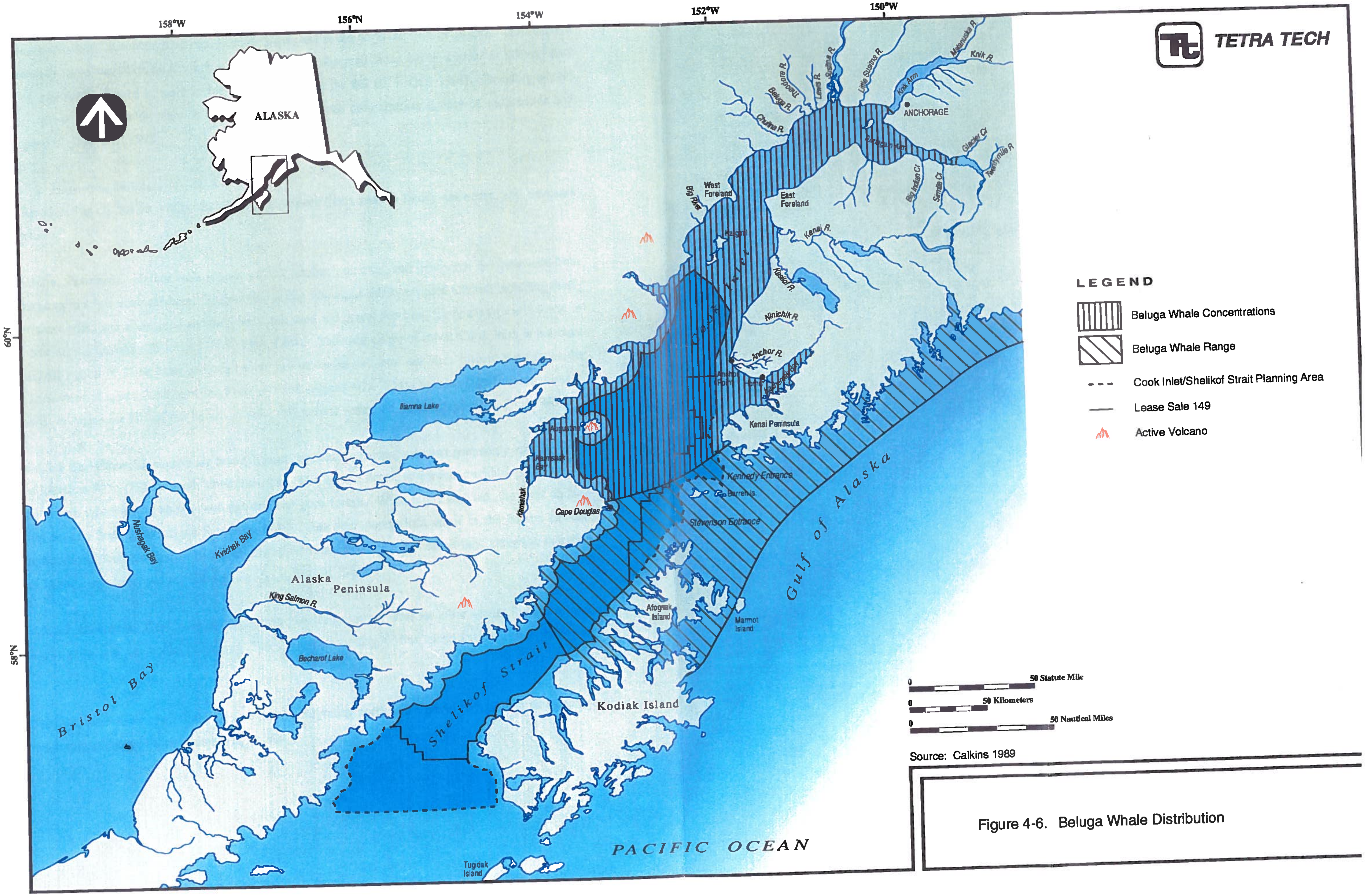


Figure 4-6. Beluga Whale Distribution

abundance, they are concentrated near Kodiak Island, and in the northeast Gulf of Alaska. Most whales probably leave the region by October as they are seldom observed in the fall or winter. It is likely that they migrate northward in early spring and southward in the fall (U.S. DOI 1984). Breeding occurs throughout the year with peaks in January and June. Their prey consists mainly of euphausiids and copepods (U.S. DOI 1992).

4.5.2 Important Habitats or Areas

The following discussion will be divided into pinnipeds (seals and sea lions), sea otters, and cetaceans (whales).

4.5.2.1 Pinnipeds. Harbor seals usually inhabit marine, estuarine, and freshwater environments from the coast to a few miles offshore. They prefer gently sloping or tidally exposed habitats including reefs, offshore rocks and islets, mud and sand bars, and sand and gravel beaches. They are typically found in water depths less than 55 meters (U.S. EPA 1984). The west shore of lower Cook Inlet is the most utilized region of Cook Inlet, although there are rookeries and haul out sites located throughout the coastal zone of lower Cook Inlet and Shelikof Strait (Figure 4-7). There are also high concentrations of seals on Augustine Island, the Barren Islands, and several areas of Kodiak Island (U.S. DOI 1983).

4.5.2.2 Sea Otters. Sea otters are found in bays, lagoons, estuaries, and most commonly inhabit waters of less than 90 m (295 ft) depth along the coast. The highest densities are found within the 40 m (131 ft) isobath where young animals and females with pups forage. When otters haul out, they rest on land and in kelp beds (Calkins and Schneider 1985). Sea otter populations occur in the Barren Islands, northern and southern Kodiak Island, southwestern Kenai Peninsula, Kamishak Bay, along the shoreline of lower Cook Inlet, and the Trinity Islands (U.S. DOI 1983).

4.5.2.3 Cetaceans. Cook Inlet and Kachemak Bay are important areas for killer whales, beluga whales, Dall's porpoises, and harbor porpoises. The waters surrounding Kodiak Island are particularly important to minke whales.

Shelikof Strait is a known route for gray whales migrating north to the Bering sea as well as a possible migratory route for fin and humpback whales.

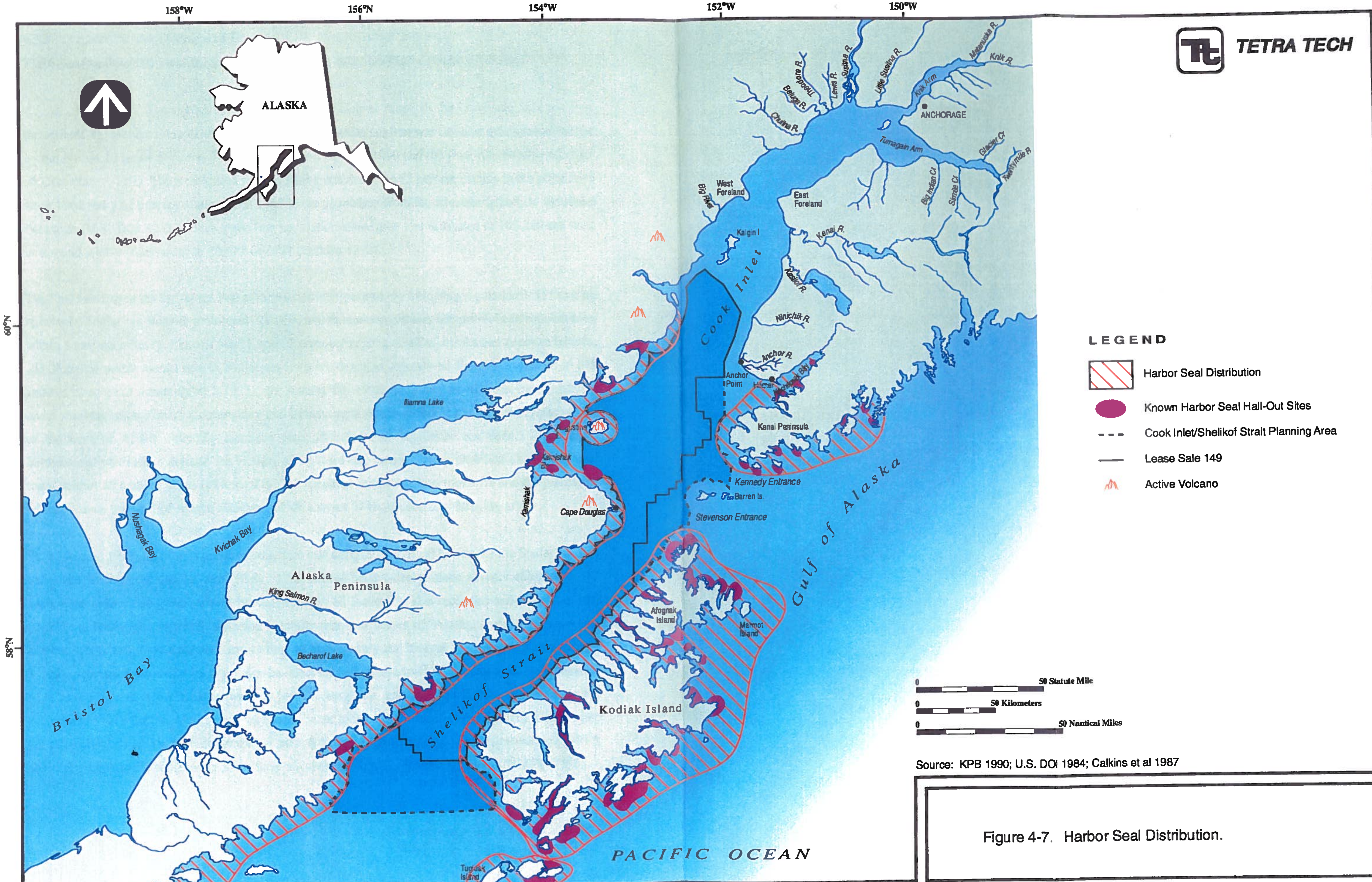


Figure 4-7. Harbor Seal Distribution.

4.5.3 Threatened and Endangered Species

The following discussion will be divided into pinnipeds (sea lions) and cetaceans (whales).

4.5.3.1 Pinnipeds. The Steller sea lion is the only pinniped found in the lease sale area listed as threatened. No pinnipeds are listed as endangered. The Steller sea lion was listed as a threatened species by the National Marine Fisheries Service (NMFS) on April 5, 1990 and the final rule became effective on December 4, 1990. The justification for this listing was due to an 82 percent decline in the population since 1960 and a 63 percent decline since 1985 in the population from the Aleutian Islands to the Kenai Peninsula (U.S. DOI 1992). Steller sea lion population abundance was estimated at 105,289 sea lions in the mid 1950's, decreasing to 20,675 in 1992 (Calkins 1992).

The final rule listing the Steller sea lion as threatened incorporated the following regulations: 1) shooting at or near Steller sea lions is prohibited, 2) with few exceptions, vessels are prohibited from entering within 3 nautical miles (5.5 km) of NMFS specified rookeries in the Gulf of Alaska and Aleutian Islands, and 3) the allowable annual take of Steller sea lions incidental to commercial fisheries is limited to 675 animals in Alaskan waters (NMFS 1993). On January 20, 1992, additional regulations were instituted under the Magnuson Fishery Conservation and Management Act to reduce the potential adverse effects of the Gulf of Alaska Federally managed groundfish fisheries to Steller sea lions. Regulations implemented pertinent to areas in the vicinity of the lease sale area include prohibition of trawling year round within 10 nautical miles (18 km) of NMFS specified Steller sea lion rookeries and the placing of restrictions on the Gulf of Alaska walleye pollock harvest in known sea lion foraging areas .

On 27 August 1993, the NMFS published the final rule designating critical habitat for the Steller sea lion under the Endangered Species Act (ESA). The critical habitat designations became effective on 27 September 1993. Designated critical habitat includes; all Steller sea lion rookeries and major haulouts (>200 sea lions) located within state and federally managed waters off Alaska, including a zone that extends 3,000 ft (0.9 km) landward and vertical of each rookery and haulout boundary, and that extends 3,000 ft seaward from rookeries and major haulouts located east of 144^{o} W longitude, or 20 m seaward from rookeries and major haulouts west of 144^{0} W longitude, and one aquatic foraging zone located exclusively in the Gulf of Alaska and two aquatic zones located in the Bering Sea/Aleutian Islands area. All of Shelikof Strait has been designated as critical habitat (Figure 8-2.) Air zones extending 3,000 ft above these terrestrial and aquatic zones have also been designated as critical habitat (NMFS 1993b).

The critical habitat designation contributes to a species conservation primarily by identifying critically important areas and by describing the features within the area that are essential to the species. There are no mandates or any specific management or recovery actions associated with the designation. Under Section 7 of the ESA, the designation of critical habitat requires Federal agencies to ensure that any action they authorize, fund, or carry out is not likely to destroy or adversely modify the designated critical habitat (NMFS 1993b).

In December of 1986, the National Marine Mammal Laboratory convened a workshop to review information on the Steller sea lion and identify possible causes for the decline in abundance. Possible causes identified were: incidental take in fisheries, deliberate shooting by fisherman, reduction in important prey species due to fishery development, entanglement in lost and discarded fishing gear and other marine debris, disease, environmental pollution, and natural changes in the marine ecosystem. The workshop concluded that information was insufficient at that time to determine the cause(s) of the decline in Steller sea lion populations (MMC 1987).

Steller sea lions accounted for approximately 90 percent (a total of 2,662 animals) of the reported incidental mortality in the Gulf of Alaska and eastern Bering Sea foreign and joint venture trawl fisheries from 1973 to 1988. Half of these sea lions (1,710 individuals) were taken in trawl nets deployed in Shelikof Strait as part of a joint venture fishery during 1982 to 1984 (Figure 4-8). Approximately 60 percent of the sea lions incidentally caught in the Gulf of Alaska were adult females. Perez and Loughlin (1991) determined that incidental take is a contributing cause of the population decline of sea lions in Alaska, however, it is unlikely that incidental take is the only factor responsible for the decline.

Other sources of mortality for sea lions include interactions with fishermen and entanglement in fishing gear. In some areas, fishermen believe the sea lions are depleting the fishery resources; therefore, the potential exists for conflicts to occur. Although shooting of sea lions is now prohibited, an estimated 305 Steller sea lions were shot by fisherman participating in the Copper River Delta salmon gill net fishery in 1978 (MMC 1987). Trawl net fragments are common marine debris that are frequently seen entangled on sea lions (Calkins 1987).

The theory with the best supporting evidence to date suggests that the sea lions are nutritionally stressed, most likely due to reduced walleye pollock abundance. From 1981 to 1988 an intense fishery existed in

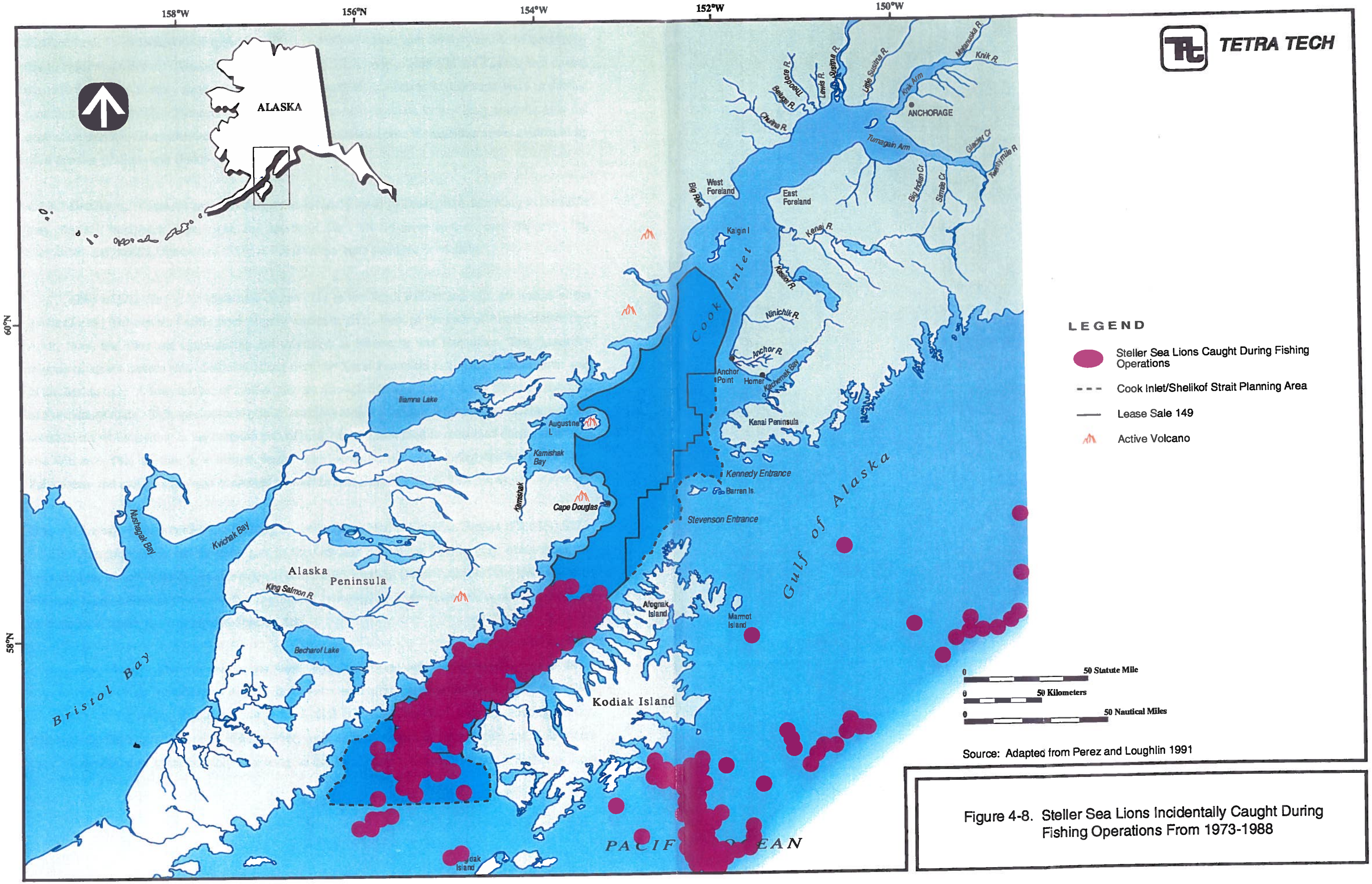


Figure 4-8. Steller Sea Lions Incidentally Caught During Fishing Operations From 1973-1988

Shelikof Strait for walleye pollock spawners, although the harvest has been severely restricted since 1986 due to reduced abundance (Kendall and Nakatani 1992). Sea lions collected in the Kodiak area during the 1980's had significantly smaller body size than individuals monitored in 1970 and were in anemic condition (Calkins 1992). Numbers of pups produced has also declined, which likely contributes to the population decline. The reduction in fecundity may be correlated with the nutrition stress evidenced by adult females (Calkins and Goodwin 1988).

4.5.3.2 Cetaceans. There are seven whale species currently listed as Endangered according to the ESA: gray, fin, sei, humpback, blue, right, and sperm whales. Of the seven species, only the gray, fin, humpback, and possibly the sei are likely to occur in the lease sale area or vicinity.

Gray whale. The gray whale now occurs only in the North Pacific and adjacent waters of the Arctic Ocean. The eastern Pacific stock of gray whales migrates through the Gulf of Alaska area during April, May, and June and again during fall migration in November and December. They generally migrate along the eastern side of Kodiak Island from the Kenai Peninsula to Unimak Pass on their way to the Bering Sea. A low number of whales migrate through Shelikof Strait via the Kennedy Entrance as a secondary route. This species usually migrates close to shore and is a summer range feeder building up fat layers while feeding in the northern part of their range. Little food is consumed during migration and winter. This species is a bottom feeder with benthic amphipods being the preferred prey. Polychaetes and molluscs are also consumed as well as schooling fish (U.S. DOI 1984).

Gray whales have been proposed for delisting by the National Marine Fisheries Service [FR 58(4):3121-3126]. This proposal is due in large part to the fact that the eastern Pacific gray whale stock has recovered to, or now exceeds, its size prior to commercial whaling (Tetra Tech 1993b). Until the U.S. Fish and Wildlife Service concurs with this proposal, however, the gray whale will continue to be listed as endangered under the Endangered Species Act.

Fin whale. The fin whale has been protected from commercial whaling since 1976. Concentrations occur from May to August in the summer feeding range in the Gulf of Alaska. Peak occurrences during spring migration occur in the Kodiak Island/northern Gulf region beginning in May. Although the fall migration begins in September, most animals remain in the Aleutian and Gulf waters until November with some possibly wintering in the southeastern Aleutian Islands. Sightings have occurred in nearshore waters east of Kodiak Island, in lower Cook Inlet, and in Shelikof Strait. Fin whales are opportunistic feeders taking euphausiids, copepods, fish and squid. They feed primarily on euphausiids which form large swarms over the continental shelf where upwelling occurs (U.S. DOI 1992).

Humpback whale. Humpback whales in the Gulf of Alaska aggregate in two areas in the vicinity of the sale area: the Portlock and Albatross Banks areas in the eastern Aleutian Islands and off the northeastern end of Kodiak Island. Southward migrations out of the Gulf of Alaska and Kodiak areas to wintering grounds off Mexico and Hawaii usually start in December. Mating and calving occur in the winter when the whales are located in the warm waters of their southern range (U.S. DOI 1984). Humpbacks feed primarily on euphausiids, amphipods, mysids, and fish such as herring, capelin, cod, and sand lance. They are thought to feed mainly during the summer at the water surface or in the mid-water region (U.S. DOI 1992).

Sei whale. The largest population of sei whales occurs just east of Portlock Bank (outside of the lease sale area) in summer. The east Pacific stock migrates northward east of Kodiak Island during April through June. The whales migrate through the area again during the fall southward migration in November and December. In spring, substantial numbers of whales occur in the waters off the northeast coast of Kodiak Island. These waters are within the Sei's migration corridor which extends near the eastern shore of the Kenai Peninsula and along the eastern shore of Kodiak Island (U.S. EPA 1983). Sei whales are mainly surface feeders. The principal prey species include copepods, euphausiids, and fish.

4.6 SUMMARY

Phytoplankton communities in the lease sale area are dominated by diatoms, with dinoflagellates, microflagellates, and other classes and families of phytoplankton also being present. Kachemak Bay is the most productive area in lower Cook Inlet. Several herbivores in the lease sale area, including zooplankton, benthic invertebrates, and waterfowl, are dependent upon phytoplankton.

Copepods are the dominant zooplankton species in the lease sale area. Fish eggs and larvae quantities vary throughout the year and euphausiids are most abundant in the summer. Lower Cook Inlet and Shelikof Strait are important areas of abundance for a variety of species. Zooplankton are prey for fish, shellfish, marine birds and mammals. Euphausiids are essential prey in the diets of yellowfin sole and minke whales, whereas mysids are the principal prey of walleye pollock and halibut.

Several benthic species in the lease sale area are harvested commercially: Tanner crab, Dungeness crab, weathervane scallop, and shrimp. Species frequently harvested for subsistence purposes include clams, crabs, cockles, and shrimp. Kamishak Bay, Kachemak Bay, and areas of Shelikof Strait are important habitats for Tanner, Dungeness, and king crabs. Five species of shrimp are commercially harvested from Kachemak Bay, although populations of shrimp and king crab have been declining in recent years. Amphipods, molluscs, crabs, ophiurids, shrimp, and other benthic species are important prey items for higher trophic levels as well as mediators for nutrient recycling.

The fish assemblages in Cook Inlet and Shelikof Strait are dominated by demersal species, with walleye pollock, yellowfin sole, and halibut being the most abundant species. Commercially harvested fish include chinook salmon, coho salmon, chum salmon, sockeye salmon, pink salmon, walleye pollock, halibut, and Pacific herring. Salmon, steelhead trout, and Dolly Varden are important sport fish. Shelikof Strait is an important spawning area for walleye pollock. Species important as prey for higher trophic levels include sand lance and capelin, as well as previously mentioned species.

Over 60 seabird colonies are located in the lower Cook Inlet region and approximately 120 bird colonies have been identified in the Shelikof Strait region. The most abundant species are fork-tailed storm petrel, tufted puffin, Leach's storm petrel, common murre, black-legged kittiwake, and horned puffin. Other common seabirds in the lease sale area include shearwaters, fulmars, cormorants, gulls, terns, guillemots, murrelets, and auklets. Seabirds feed primarily on marine invertebrates and fishes.

Waterfowl in the lease sale area include ducks and geese. Many diving ducks overwinter in Kachemak Bay. Other areas of importance to waterfowl include lower and upper Cook Inlet, Kodiak Island, and the eastern side of the Alaska Peninsula. Waterfowl feed primarily on crustaceans, molluscs, aquatic insects, and fish.

Seventeen species of cetaceans, three pinniped species, and one mustelid (the sea otter) are found year round in the Cook Inlet/Shelikof Strait Planning Area, or use this area as a potential migratory route. Frequent prey for marine mammals in the Gulf of Alaska include copepods, euphausiids, herring, cod, walleye pollock, capelin, salmon, cephalopods, and crustaceans.

The Steller sea lion, harbor seal, Dall porpoise, harbor porpoise, and beluga whale are present throughout the year in the Cook Inlet/Shelikof Strait Planning Area. The northern fur seal, killer whale, minke whale, gray whale, fin whale, and humpback whale are seasonal migrants.

Species found or potentially occurring in the lease sale area listed as threatened or endangered pursuant to the ESA include Arctic peregrine falcon, American peregrine falcon, Steller sea lion, gray whale, fin whale, and humpback whale. The Steller's eider and the beluga whale are listed as candidate species.

5.0 POTENTIAL IMPACTS OF DRILLING MUD ON ARCTIC MARINE ORGANISMS

The determination of "unreasonable degradation" of the marine environment is to based upon consideration of the ten criteria listed in chapter 1.0. This chapter provides an assessment pertinent to consideration of the *ocean discharge* criteria shown below:

- **Criteria # 1:** "The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged"

- **Criteria # 2:** "The potential transport of such pollutants by biological, physical, or chemical processes"

- **Criteria # 6:** "The potential impacts on human health through direct or indirect pathways"

Drilling muds, or fluids, are complex mixtures of clays and chemicals, and their potential impact on marine organisms has been examined in several studies. Recent reviews of studies conducted in federal OCS areas include Neff (1982), National Research Council (1983), Petrazzuolo et al. (1985), and Parrish and Duke (1990). Other studies identified in the Sale 88 ODCE (U.S. EPA 1984, Section 5) also present data from federal OCS areas.

This section briefly summarizes studies of both the chemical and physical effects of drilling mud on Alaskan marine organisms. It includes lethal and sublethal toxicity, potential for bioaccumulation, possible human health impacts, and potential physical effects such as smothering of the benthos, sediment alteration, and indirect effects through food supply reduction. Impacts on various taxonomic groups are discussed in greater detail in the Diapir Field Sale 87 ODCE (U.S. EPA 1984b, Section 5 and Appendices A-E) and Norton Basin Sale 100 ODCE (U.S. EPA 1986, Section 5 and Appendices A-E). Studies of chemical effects (toxicity and bioaccumulation) of drilling mud discharges are discussed in detail in the Sale 100 ODCE (U.S. EPA 1986, Section 5 and Appendix F).

Research conducted in previous studies provides sufficient information to make reasonable judgments concerning some of the effects of discharged drilling mud on aquatic organisms, although these tests often have limitations. One general difficulty is that exposure to drilling mud may cause both chemical toxicity and physical effects. In tests of some species, particularly larvae, it may be difficult to separate chemical toxicity from physical effects such as burial of the test organism, clogging of gills, and abrasion (U.S. EPA 1986, p. 5-1). Physical effects on marine organisms should, therefore, be considered in conjunction with chemical toxicity when evaluating the environmental impacts of drilling mud discharges.

Field studies generally are not designed to distinguish between chemical and physical effects of drilling mud and cuttings discharges. Limitations and descriptions of previous studies may be found in the Sale 88 ODCE (U.S. EPA 1984).

5.1 CHEMICAL TOXICITY OF DRILLING MUD

A variety of Alaskan marine organisms have been exposed to drilling mud in laboratory or field experiments. Most of these studies have addressed short-term acute effects in a relative or "screening" sense, with little effort directed at separating chemical from physical causes. [In aquatic toxicity tests, a response measuring lethality observed in 96 hours or less is typically considered acute (U.S. EPA 1990)]. A few studies have looked at chronic sublethal effects and bioaccumulation of heavy metals from drilling mud. Chronic refers to a stimulus that lingers or continues for a relatively long period of time, often one-tenth of the life span of an organism or more (U.S. EPA 1990). Results are typically reported as LC50s (concentrations lethal to 50 percent of the test organisms) or median effective concentrations [EC50s (concentrations at which a designated effect is displayed by 50 percent of the test organisms)]. Because drilling discharges are episodic and typically only a few hours in duration (Jones & Stokes 1990, p. 44), organisms that live in the water column are not likely to have long-term exposures to drilling muds; risks to these organisms are best assessed using acute toxicity data. Benthic organisms, particularly sessile species, are likely to be exposed for longer time periods; risks to these organisms are best assessed with chronic toxicity data.

5.1.1 Acute Lethal and Sublethal Effects

The effects of drilling muds on biological organisms are most commonly assessed by conducting acute laboratory toxicity tests. Unfortunately, in many cases, comparison of toxicity test results obtained in different studies are difficult because different drilling muds were used, the animals were exposed to different portions of drilling mud (liquid, suspended particulates, or solids) that may have been prepared in a different manner, or experimental procedures differed between investigators. Nevertheless, results obtained in the majority of studies to date have not shown drilling mud to have a high degree of acute toxicity (U.S. EPA 1988, p. 5-2). For example, Parrish and Duke (1990, p. 215) reviewed research findings on the toxicity of drilling muds used in the Gulf of Mexico and concluded that available models suggest that discharges made from oil platforms in open, well-mixed waters deeper than about 20 m (66 ft) will result in no detectable acute effects, except within a few hundred meters of the point of discharge.

The current NPDES permit for the Cook Inlet/Gulf of Alaska areas has incorporated a standard acute toxicity test using the mysid *Mysidopsis bahia*. Under provisions of the current NPDES permit, U.S. EPA Region X has not authorized the discharge of drilling fluids which would, in the Region's best professional judgement, might exceed a toxicity criterion of 30,000 ppm spp (suspended particulate phase). Drilling mud toxicity data compiled by U.S. EPA, Region X from Alaskan exploratory and production wells indicate that the muds used in all current and recent operations did not exhibit substantial acute toxicity to *Mysidopsis bahia* (Tetra Tech 1993b). LC50s for the 91 valid toxicity test data points ranged from 2,704 to 1,000,000 ppm SPP (suspended particulate phase) with a mean of 540,800 ppm. Only 7 of the 91 tests had a LC50 less than the 30,000 ppm limit. The complete mud toxicity database is reproduced in Appendix C. Some of the records in this database (shaded) were not included in the above statistics due to pH or other protocol breaches, incomplete reports, etc.

In general, planktonic and larval forms appear to be the most sensitive of the Alaskan organisms that have been exposed to drilling mud in acute lethal bioassays (see Appendix D). Several examples are mentioned in the Sale 88 ODCE (U.S. EPA 1984, p. 76), including the following: the diatom *Skeletonema costatum*, which had EC50s as low as 540 parts per million (ppm) in mixed whole drilling mud and 1,600 ppm in mixed barite, a major drilling mud component (see Table 2-1); pink salmon fry (*Oncorhynchus gorbuscha*), which had a LC50 of 3,000 ppm in whole mud; and dock shrimp (*Pandalus danae*), which had a LC50 of 600 ppm when exposed to whole used drilling mud. As discussed in the Sale 87 ODCE

(U.S. EPA 1984b, p. 78), the data obtained for the dock shrimp are not considered to be representative of the generic muds that would be discharged in the Cook Inlet/Shelikof Strait Planning Area, as the mud tested was formulated with a component containing hexavalent chromium, which is highly toxic to marine life.

Not all planktonic organisms are sensitive to short-term exposure to drilling muds. Carls and Rice (1984, p. 45) found several drilling muds to have low toxicity to the larvae of six Alaskan species of shrimp and crab. The 96-h LC50s for the suspended particulates phase of a drilling mud seawater mixture ranged from 500 to 9,400 ppm. Toxicity was far less when the particulates were removed: the 96-h LC50s ranged from 5,800 to 119,000 ppm.

The LC50s for these Alaskan species can be compared to estimated concentrations of whole mud at the edge of the mixing zone [100 m (328 ft) from the point of discharge]. In the Sale 109 ODCE (U.S. EPA 1988, p. 5-4), drilling mud concentrations at the edge of the mixing zone were estimated to be approximately 4,000 ppm for a dilution (dissolved components) of 248:1. A similar calculation for dilutions predicted for open-water discharge in the Cook Inlet/Shelikof Strait Lease Sale area (Case 28, Table 3-2) gives an estimated mud concentration of 2,097 ppm for dissolved components and 992 ppm for solid components at the edge of the mixing zone. While the LC50s for the diatom species and the dock shrimp lie within the estimated range calculated for drilling mud concentration, it is unlikely that organisms will be exposed to these concentrations for periods of time typically used to determine acute toxicity (96 h), as drilling mud discharges are episodic with durations of only a few hours (Jones & Stokes 1990, p. 44).

There are several Alaskan taxa that have not been exposed to drilling mud but may be relatively sensitive. The temperate copepod, *Acartia tonsa*, has exhibited one of the lowest LC50s (100 ppm) of any organism in a drilling mud test (see Sale 87 ODCE, U.S. EPA 1984b, p. 79). Alaskan copepods have not been tested, but there is no reason to believe their tolerances would fall outside variability in tolerances of other marine copepods (i.e. *A.* tonsa).

The majority of Alaskan organisms, with the exception of copepods, apparently show high tolerance to acute exposure to drilling mud (see Appendix D). Sublethal effects observed following acute exposure have included alteration of respiration and filtration rates, enzyme activities, and behavior (see U.S. EPA 1984b, Appendix F, Table F-2).

5.1.2 Chronic Effects

Few studies have evaluated impacts on Alaskan species following chronic exposure to drilling muds. All the species that have been tested are invertebrates. The test results are summarized in Appendix A of the Sale 88 ODCE (U.S. EPA 1984). The lowest reported concentration of drilling mud producing a significant sublethal chronic effect was 50 ppm for 30 days of continuous exposure with bay mussels, and there was no attempt to separate chemical from physical effects (U.S. EPA 1988, p. 5-3).

A recent laboratory study examined the chronic toxicity of cuttings from Beaufort Sea wells on the sand dollar (*Echinarachnius parma*) (Osborne and Leeder 1989). Exposure to mixtures as low as 10 percent cuttings/90 percent sand were found to affect the survival of the benthic organisms, with 100 percent mortality occurring within 23 days in some test cases.

5.1.3 Bioaccumulation

Bioaccumulation of heavy metals and petroleum hydrocarbons are two topics of concern. Existing data for Alaskan species are inadequate for quantification of potential long-term effects. However, the available data suggest that there appears to be a toxicologically insignificant hazard to aquatic life (e.g., invertebrates, fish, marine mammals, and birds) from consumption of aquatic organisms that have been exposed to discharges from exploratory oil drilling operations. The same conclusion applies to commercial, recreational, and subsistence harvests. The basis for these conclusions is provided in the Sale 100 ODCE (U.S. EPA 1986) and in the discussion below.

Heavy metals and petroleum hydrocarbons undergo varying degrees of bioconcentration [the process whereby chemical substances enter aquatic organisms directly from the water through gills or epithelial tissue (Macek et al. 1979, p. 252)] and bioaccumulation [the process that includes bioconcentration along with any increase in chemical residues from dietary intake (Macek et al. 1979, p. 252)] in marine organisms. Organisms equilibrate with the food and water concentrations of the chemicals to which they are exposed. The chemical residues retained by the organisms are believed to be a function of their lipid contents, and concentrations of certain chemical-binding proteins and peptides that are involved in detoxification (Brown et al. 1985, p. 365; Gossett et al. 1983, p. 389; Veith et al. 1979, p. 1044).

Bioconcentration is considered the main route of uptake (Macek et al. 1979, p. 251), with dietary sources usually supplying a minor fraction of the body burden. When marine organisms are transferred from higher to lower concentrations of heavy metals, they will depurate (eliminate via excretion) the substances to varying degrees. Only for certain compounds is depuration so slow that tissue concentrations remain elevated for the life of the organism (U.S. EPA 1986, p. F-25).

5.1.3.1 ***Heavy Metals.*** A variety of heavy metals occur in drilling muds (see Chapter 2.0). Metal accumulation studies for Alaskan species are discussed in Appendix F of the Sale 83 ODCE and results of investigations on both Alaskan and non-Alaskan species are summarized in Appendix F of the Sale 87 ODCE (U.S. EPA 1984b) and Appendix A Table A-3 of the Sale 88 ODCE (U.S. EPA 1984).

Bioaccumulation of mercury, one of the few metals known to bioaccumulate and undergo biomagnification, has not been studied in laboratory tests of drilling mud using Alaskan species. A recent study by Neff et al. (1985) examined the bioaccumulation of mercury and other trace metals found naturally in barite, the major weighting agent in most water-based drilling muds, using four benthic species from Massachusetts waters. Two of these species, the sand worm (*Nereis virens*) and the soft-shell clam (*Mya arenaria*), are congenic (same genus) in Alaskan waters. Mercury and arsenic appeared to be the least bioavailable of all the metals tested. Metals did not show consistent and statistically significant bioaccumulation in any of the four species of test animals. Although mercury discharged in drilling muds is largely inorganic and not bioavailable, virtually any mercury compound may become a bioaccumulation hazard for organisms since bacteria common to most natural waters are capable of biomethylating the metal (Callahan et al. 1979). Additional studies need to be performed to determine the degree to which discharge of drilling muds to Alaskan waters, which contain on average 0.1 mg/kg mercury (Table 2-2), may increase the possibility for its bioaccumulation in Alaskan marine organisms. Mercury exists naturally in sediments in many areas of Alaska and a variety of marine mammals have been found to have tissue concentrations in excess of FDA standards for human consumption (U.S. EPA 1984b, Appendix F).

Cadmium can accumulate to high levels in marine organisms (Olla et al. 1988), can biomagnify, and is toxic to humans. Trace metal concentrations, including cadmium, have been monitored in several Beaufort Sea invertebrate species in 1986, 1987, and 1989 (Boehm et al. 1990, p. 5-18). No consistent trend in cadmium bioaccumulation was apparent between the 1986-87 data and the 1989 data even though the two-year gap in the monitoring program between 1987 and 1989 was characterized by an increased level of exploratory oil drilling (Boehm et al. 1990, p. 5-51). Cadmium concentrations ranged from 0.8 mg/kg for the amphipod *Anonyx* in 1986-87 to 14 mg/kg for the clam *Astarte* in 1986-87. Table 2-2 indicates that drilling muds may contain cadmium concentrations as high as 12 mg/kg. If drilling mud discharges significantly increase cadmium concentrations in marine or anadromous organisms eaten by people, adverse impacts to human health could ensue. The Sale 100 ODCE for Norton Basin, Alaska (U.S. EPA 1986, p. F-25) stated that the potential threat to human health accruing from consumption of fish and shellfish contaminated with cadmium, chromium, lead, zinc and barium is not serious enough to warrant FDA setting "action levels" for these metals because of the magnitude of the bioconcentration factors (BCF) (the ratio of the tissue metal concentration to the metal concentration in the test media), the rapidity of depuration, and the absence of bioaccumulation for these metals.

Barium is a major constituent of drilling muds and is the metal that has been observed to accumulate to the greatest extent in organisms exposed to drilling mud (U.S. EPA 1984b, p. 56). Laboratory studies of barium uptake have not been performed with Alaskan species; however, 350-fold accumulations have been reported in other species. A field study found no statistically significant increase in barium concentrations for Beaufort Sea clams and amphipods during a period of exploratory drilling from 1986-87 to 1989 (Boehm et al. 1990, p. 5-18). Concentrations ranged from 21 mg/kg for the clam *Astarte* in 1986-87 to 117 mg/kg for the clam *Macoma* in 1986-87. Barium is less toxic to humans than either mercury or cadmium. Calculations provided in the Sale 87 ODCE (U.S. EPA 1984b, Appendix F) estimate that 5-15 kg (11-33 lb) of contaminated seafood would need to be consumed within a very short time [biologic half-life is less than 24 hours for humans (Goyer 1986)] to cause an adverse effect in a human.

5.1.3.2 Petroleum Hydrocarbons. A major question surrounding the disposal of oil-based muds is the potential for hydrocarbon bioaccumulation. The polycyclic aromatic hydrocarbons (PAH) are of particular concern due to their mutagenic and carcinogenic nature. PAH concentrations were measured in several Beaufort Sea invertebrate species in 1984-86 and 1989; the time period between the studies was characterized by an increased level of exploratory drilling. Animals which fed from the water column (the clams *Astarte* and *Cyrtodaria*) and animals which resided at the sediment-water interface (the clams *Macoma* and *Portlandia*, and the amphipod *Anonyx)* were both analyzed. In general, the 1989 PAH values were either lower or similar to the two-to-three year mean values from 1984-86. These results indicate that the PAH bioaccumulation potential for various Beaufort Sea invertebrate species is small. Payne et al. (1989) studied the bioaccumulation of PAH in winter flounder *(Pseudopleuronectes americanus)*, an Atlantic fish. Their results also suggest there is minimal potential for bioaccumulation of PAH in demersal fish.

5.1.4 Mineral Oil in Drilling Muds

In the past, the oil industry has added diesel oil to drilling fluid systems to free stuck drilling pipe and for other specialized applications. Diesel oil is highly toxic to aquatic life, and much of the toxicity of drilling muds has been attributed to its presence. In a recent evaluation of the effects of drilling fluids on marine organisms, Parrish and Duke (1990, p. 207) reported that in most cases, mortality of test organisms was significantly correlated with the diesel oil content of drilling fluids used in the Gulf of Mexico. Because of the toxicity of diesel oil, U.S. EPA has prohibited its discharge in muds and cuttings (U.S. EPA 1988a, p. 5-5). Instead, U.S. EPA allows the use of mineral oils to free stuck pipes and the discharge of residual amounts of mineral oil pills, provided that the pill and a buffer of drilling fluid on either side of the pill are removed and not discharged. The residual mineral oil concentration in the discharged mud should not exceed 2 percent (v/v) and must comply with all permit conditions (53 FR 37857).

Mineral oils differ from diesel oils in that they contain a lower concentration of aromatic hydrocarbons (15-20 percent vs. 20-61 percent for diesel oil). In addition, saturated aliphatics (paraffinics) generally represent a larger percentage of mineral oils compared to diesel oil (U.S. EPA 1984b, p. 57). Aromatic hydrocarbons are generally more toxic and resist biodegradability to a greater degree than do paraffinics (Petrazzuolo 1983, p. 8). Research studies indicate that some mineral oils are much less acutely toxic (5 to 30 times less) to certain marine organisms than diesel oil (U.S. EPA 1988a, p. 5-6).

Despite the reduced toxicity of some mineral oils as compared to diesel oils, mineral oils do contribute potentially toxic organic pollutants to drilling muds to which they are added (see Tables 2-5 and 2-6). The potential for drilling muds containing mineral oils to violate Federal water quality criteria is discussed in Chapter 9.

Neither mineral nor diesel oils possess constituents that can be biomagnified (U.S. EPA 1988a, p. 5-6). The hazard to aquatic life from consuming organisms or inhabiting water contaminated with diesel oils is greater than that for mineral oil because the aromatics in diesel oils tend to be more soluble and biologically active than paraffinic hydrocarbons, although polynuclear aromatic hydrocarbons (PAHs) contained in mineral oils have been shown to be highly soluble in adipose tissue and lipids (Sittig 1985, p. 741). Organisms will assimilate hydrocarbons in both types of petroleum products, but the hazard associated with the residues is not expected to be significant (U.S. EPA 1988a, p. 6).

5.1.5 Likelihood of Potential Chemical Effects During Exploratory Drilling

Although most pelagic Alaskan species that have been tested are apparently tolerant of acute exposures, early life history stages of a few species have exhibited relatively high sensitivity to acute exposure to drilling mud. Chronic toxicity to pelagic species from drilling muds is also of concern. Of the chronic toxicity studies conducted, statistically significant sublethal chronic effects have been reported at concentrations as low as 50 mg/L over 30 days (U.S. EPA 1984b, Appendix F).

Although previous documents have indicated that pelagic organisms are not likely to be impacted by drilling mud discharges (U.S. EPA 1988a, p. 5-7; U.S. EPA 1984b, p. 58), the dilutions cited in some reports (e.g., Tetra Tech 1984, Appendix A) are higher by at least one order of magnitude than the dissolved-fraction dilutions provided in this ODCE (Tables 3-2). While this may indicate an increased potential for deleterious impacts to pelagic organisms, the organisms are likely to be exposed to drilling mud discharges for short time periods only.

Although exposure to drilling mud in the water column is likely to be short-term, chronic exposure to deposited solids remains a concern. Both acute lethality and chronic sub-lethality have been noted for sand dollars exposed to cuttings from Beaufort Sea wells (Osborne and Leeder 1989). Similar studies with non-Alaskan animals have also been done. For example, Atema et al. (1982) showed that long-term exposure of post-larval lobsters *(Homarus americanus)* to 7 μL/L drilling mud resulted in delays in feeding, molting, and shelter construction, and increased bouts of walking and swimming. Drilling muds and barite that were layered in depths of 1 and 4 mm (0.04-0.16 in) caused severe delays and poorer quality of shelters being constructed (Parrish and Duke 1990, p. 209).

Bioaccumulation of trace metals and PAHs by organisms exposed to exploratory drilling discharge of muds and cuttings is of concern. However, given the limited volume of mud and cuttings discharged, the ability of aquatic organisms to detoxify and depurate these compounds, and the small percentage (<0.001) of the lease area expected to be impacted by drilling discharge, bioaccumulation is not expected to significantly affect marine organisms in the Lease Sale area.

5.2 HUMAN HEALTH IMPACTS

Ingestion of organisms that have accumulated significant concentrations of heavy metals from drilling muds is the potential principal source of adverse human health effects caused by discharge of drilling mud into the marine environment. Overall, significant impacts to human health are not expected to result from the limited discharges of drilling mud that characterize the exploratory phase in the Arctic Lease Sales. As discussed in the Sale 88 ODCE (U.S. EPA 1984, p. 82), the hazard associated with consuming fish and shellfish contaminated with metals or petroleum hydrocarbons is expected to be low. The reasons for this assessment are that bioconcentration factors for heavy metals other than methylmercury and for mobile aromatic hydrocarbons such as benzene are too low to warrant concern about biomagnification; mercury, which is potentially the most hazardous metal, is a relatively minor constituent of drilling muds; and the areas affected by exploratory drilling discharges are too small to contribute substantially to the diet of fish or shellfish harvested by commercial, recreational, or subsistence fisheries.

5.3 PHYSICAL EFFECTS OF DISCHARGE

During exploratory drilling, biological impacts are most likely to occur as a result of the physical effects of discharge of drilling mud and cuttings. Other discharges are typically of low volume, nonpolluting, or treated prior to discharge to remove pollutants.

The following discussion briefly summarizes the effects of discharges on biota by major type of physical effect. More detailed effect-based discussion is found in the Sale 88 ODCE (U.S. EPA 1984), including additional information presented by taxon in Appendices A-E.

5.3.1 Exposure to Suspended Solids

As discussed in Chapter 3, dispersion and dilution of the discharge plume is expected to be rapid, and discharges intermittent and localized. Therefore, adverse physical effects to biota from drilling discharge should be limited to the nearfield vicinity of exploratory drilling. Within this region, zooplankton and fish larvae near the discharge may experience altered respiratory or feeding ability due to stress, abrasion, or clogging of gills and feeding apparatus. Phytoplankton entrained in the discharge plume may have reduced productivity due to decreased light availability and exposure to elevated concentration of trace metals. These impacts should result in negligible impacts to populations in the region, as impacts should be restricted to the immediate vicinity of the discharge, and discharges are expected to be intermittent. Mobile invertebrates, fish, birds, and mammals presumably will avoid the discharge plume if conditions become stressful. Therefore, impacts are also expected to be negligible to these organisms.

Infaunal or sessile organisms near the discharge most likely will be adversely impacted by drilling discharge, but the area affected should be limited to the region in the immediate vicinity of the discharge.

5.3.2 Exposure to Deposited Solids

5.3.2.1 Smothering of Benthos. Many benthic invertebrates are relatively sedentary and sensitive to environmental disturbance and pollutants. Short-term effects of drilling muds and cuttings on benthic invertebrates are expected to include smothering of biota, especially by cuttings in the area near the discharge. As discussed in the Sale 100 ODCE (U.S. EPA 1986b, p. 5-13), deposition is likely to reduce abundances of benthos such as polychaetes, molluscs, and crustaceans, and may affect demersal eggs of various benthic species and fish. The greatest impact would be expected downcurrent along the plume's median axis.

Little information is presently available concerning the effects of various deposition depths on benthic communities. Most studies that have investigated deposition impacts on benthos have examined deposition of dredged materials (Hale 1972; Kranz 1974; Mauer et al. 1978; Oliver and Slattery 1973; Saila et al. 1972; Schafer 1972; Schulenberger 1970, Wilber 1992). These studies indicate that the response to deposition and survival following such an event is species-specific. Of the species examined, burial depths from which organisms were able to migrate to the surface ranged from 1 to 32 cm (0.4 to 12.6 in). If it is assumed that most benthos are not adversely affected by deposition of drilling muds less than 1 cm (0.4 in), benthos in the vicinity of the discharge receiving deposition in excess of this amount may be impacted by drilling activities.

The "mixing zone" concept incorporated into most NPDES permits, including those for oil and gas exploration, generally permits adverse impacts to benthic communities within the mixing zone. For the purposes of the general oil and gas permits, the mixing zone has been defined as a circle with a 100 m (328 ft) radius. Adverse impacts to benthic communities outside the mixing zone are not permitted. If it is assumed that solids deposition of greater than 1 cm (0.4 in) represents an "adverse impact" to benthos, solids deposition outside the mixing zone should be less than 1 cm (0.4 in) avoid potential adverse impacts to benthic organisms.

It is not possible to accurately predict the area within the entire Cook Inlet/Shelikof Strait Planning Area receiving deposition exceeding 1 cm (0.4 in) due to the uncertainty of drilling rig location and site-specific oceanographic conditions, however, water depths greater than 40 m (131 ft) are not expected to receive drilling mud deposition exceeding 1 cm (0.4 in). A "worst case" scenario can be developed by determining the area that would be affected if the total volume of discharge were evenly spread to a depth of 1 cm (0.4 in). An estimated 1,234 m^3 of drilling muds (calculated from Table 2-7), using a mud density of 2.09 g/L (17.4 lb/gal) is expected to be produced from the six exploratory and two delineation wells estimated from the Industry Alternative Scenario. Evenly distributed to a depth of 1 cm (0.4 in), this would cover a maximum of 12 ha (30 ac). Since the Cook Inlet/Shelikof Strait Planning Area encompasses approximately 1.5 million ha (3.7 million ac), approximately 0.0008 percent of the lease area would potentially receive greater than 1 cm (0.4 in) deposition of drilling mud for this "worst case" scenario. The values given above do not include cuttings, and thus, can be considered underestimates, although cuttings are expected to be deposited within the mixing zone and would not be expected to contribute substantially to the total solids deposition outside the mixing zone (Jones & Stokes 1990). Given the extremely small percentage of the planning area expected to be covered by greater than 1 cm (0.4 in) of deposited solids, the inclusion of cuttings in the calculations would not alter the conclusion that the impacted area is extremely small relative to the entire planning area.

5.3.2.2 Demersal Fish Eggs. Walleye pollock spawning locations have been identified in Shelikof Strait (Figure 4-1) in the Lease Sale area. A number of other important species, including most cottids, Pacific cod, rock sole, and sand lance also release demersal eggs. Smothering of demersal eggs could have a substantial adverse impact on these demersal species and other aquatic organisms that prey upon these fish. Drilling wastes that are discharged during spawning and egg production periods, have the most potential to adversely affect these species. Exploratory drilling operations in Shelikof Strait have a greater likelihood to adversely impact demersal fish spawning activities because spawning grounds are more commonly found in these waters. Discussion of the potential relative sensitivity of demersal eggs to smothering effects, and a worst case evaluation, appears in the Sale 87 ODCE (U.S. EPA 1984b, p. 88).

5.3.3 Alteration of Sediment

Alteration of sediment characteristics is expected to impact the benthic community structure more subtly, but at greater distances from the point of discharge, than smothering. Benthos would be the group most affected by changes in the sediment, but other organisms may be affected as well. Impacts to benthic communities could conceivably affect epibenthic and pelagic invertebrates, fish, birds, and mammals that rely on benthic invertebrates for food.

Judging from impacts observed in other OCS areas, the magnitude of the observed impact depends on the total area receiving mud deposits, the depth of deposition, the difference between native sediments and deposited mud and cuttings (influenced by grain size and composition), and the length of time during which detectable changes in sediment composition occur (U.S. EPA 1984, p. 87).

As noted in the Sale 88 ODCE (U.S. EPA 1984, p. 87), indirect impacts could also occur with respect to ecosystem interrelationships resulting from behavioral changes, but these would be difficult to observe and correlate with drilling mud disposal. Altered sediment composition may inhibit larval recruitment or feeding and survival of benthic species in some areas.

Further discussion of issues associated with sediment alteration may be found in the Sale 88 ODCE (U.S. EPA 1984, pp. 87-88). Existing data summarized from other OCS areas (see U.S. EPA 1984b,

Appendix B) indicate that impacts may occur, but are likely to be localized. The greatest effect is expected in the area receiving cuttings deposits. It is unlikely that sediment alteration during exploratory drilling will significantly impact populations of benthos in the deeper areas (U.S. EPA 1984).

5.3.4 Cumulative Impacts of Solids Deposition

Impacts of any kind from a single drilling site are likely to be localized. Although benthic organisms may be smothered or develop body burdens of heavy metals above background in localized areas, the benthic communities in the Lease Sale area would not be expected to decline significantly. However, no data exist to evaluate the potential impact to benthic communities for several drilling sites that would be located close enough to each other that dispersion of the discharged muds from all of the sites would cumulatively cover a large contiguous portion of the area.

Impacts from bioaccumulation, toxicity and changes in community structure could be cumulative spatially and over the short term, but it is unlikely that these impacts would be persistent. In addition, lessening impacts can reasonably be expected over time. Additional issues and informational shortfalls are treated in the Sale 87 ODCE (U.S. EPA 1984b, pp. 89-90). Although more complete knowledge would be of value in assessing the magnitude and significance of cumulative environmental impact, available data indicate that unreasonable degradation is not likely to occur in areas of adequate dispersion and dilution (U.S. EPA 1984).

5.3.5 Indirect Effects Through Food Supply Reduction

The quantity of benthic organisms preyed upon by other species could be reduced in the area of the discharge if benthos migrate from the area, or experience increased mortality or decreased recruitment, through smothering, toxicity, or alteration of sediment grain size characteristics. Issues affecting temporal or areal extent of such impacts are discussed in the Sale 88 ODCE (U.S. EPA 1984, pp. 88-89).

The degree of food supply reduction caused by discharges of drilling muds and cuttings is unknown, as the size of the affected area and severity of impacts are by necessity speculative. However, a significant reduction of food supplies (benthic organisms) is judged unlikely, given that under a worst case scenario, only a small portion the Lease Sale area [(approximately 0.0008 (3.0 ac) percent of the Lease Sale area)] would receive deposition depths greater than 1 cm (0.4 in).

5.4 SUMMARY

Drilling muds can adversely affect marine life provided exposures are sufficiently long and concentrations sufficiently high. Effects can occur due to chemical toxicity, clogging of feeding or respiratory structures with particulates, smothering, and modifications of habitat. The most toxicologically important constituents of drilling muds are aromatic compounds and heavy metals.

Overall, larvae and planktonic organisms are apparently the most sensitive to drilling discharges, and effects on them will primarily be a function of dilution and dispersion of the discharge plume. It is unlikely that the chemical toxicity of drilling muds will substantially impact pelagic organisms near exploratory drilling sites because concentrations of toxic constituents are estimated to be below levels known to be acutely lethal at the edge of the 100 m (328 ft) mixing zone.

The benthic community in the immediate vicinity of the drilling discharge is the most likely to be impacted because of exposure to large amounts of drilling muds and cuttings. The results of the modified OOC model case runs indicate that benthic communities outside the prescribed 100 m (328 ft) mixing zone could be adversely impacted because they would receive greater than 1 cm (0.4 in) of deposited solids.

It is not possible to accurately predict the area within the proposed Lease Sale which would receive deposition amounts detrimental to benthos, because of the uncertainty of drilling rig locations and because deposition depends on site-specific oceanographic conditions. If it is assumed that a deposition depth of 1 cm (0.4 in) would be detrimental to benthic organisms, a worst-case scenario calculation indicates that less than 0.0008 percent of the total area proposed for the Lease Sale area would potentially be adversely impacted. Solids deposition exceeding 1 cm (0.4 in) in thickness may occur outside the 100 m (328 ft) mixing zone boundary for discharges in water depths 40 m (131 ft) or less.

Discharges in spawning locations, particularly Shelikof Strait, during critical periods, could severely impact the populations of demersal fish species, as well as other aquatic organisms that prey upon these species, by smothering the eggs, or emerging larvae.

Uncertainty exists regarding the long-term toxicological effects of drilling muds deposited on the seafloor. Of particular concern are the impacts arising from chronic leaching of metals, hydrocarbons, and the most persistent biocides in drilling mud deposited on the bottom. In addition, insufficient evidence exists to demonstrate that data from short-term acute toxicity tests reveal subtle adverse effects at the ecosystem level of biological complexity (Parrish and Duke 1990, p. 216).

6.0 THREATENED AND ENDANGERED SPECIES

The determination of"unreasonable degradation" of the marine environment is to be based upon consideration of ten criteria listed in Chapter 1.0. This chapter provides information pertinent to the consideration of the *ocean discharge* criterium shown below:

- **Criteria #3:** "The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain".

As discussed in Section 4.4, there are three species of birds that are located in the vicinity of the Lease Sale area either as a seasonal migrant, the Steller's eider, or possible seasonal migrant, the Arctic and American peregrine falcons. The Steller's eider is listed as a "candidate species" receiving category 1 status, due to other species currently having higher priority for consideration for placement upon the endangered species list as a threatened or endangered species. The Arctic and American peregrine falcons are listed as threatened and endangered, respectively.

There are seven species of cetaceans currently listed as endangered of which four occur or have the potential for being located in the Lease Sale area, the gray, humpback, fin, and sei whales. More detailed descriptions of these species may be found in Section 4.5.3.

The beluga whale is presently listed as a "candidate" species and studies are currently being conducted to determine if reclassification is warranted. A more specific description of this species may also be found in Section 4.5.3.

The Steller sea lion which is located throughout the Lease Sale area is listed as a threatened species. Proposed critical habitat exists in Shelikof Strait and around major rookeries. A more detailed discussion of this species may be found in Chapter 4.0, section 4.5.1.3.

The Environmental Protection Agency is developing a biological evaluation of threatened and endangered species in the Lease Sale 149 area and candidate species for compliance with Section 7 of the Endangered Species Act. This evaluation, when available, will supplement information provided in this Chapter.

7.0 COMMERCIAL, RECREATIONAL, AND SUBSISTENCE HARVEST

The determination of "unreasonable degradation" of the marine environment is to be based upon consideration of the ten criteria listed in chapter 1.0. This chapter provides information pertinent to consideration of the two *ocean discharge* criteria shown below:

- **Criteria #7:** "Existing or potential recreational and commercial fishing, including finfishing and shellfishing"

- **Criteria #8:** "Any applicable requirements of an approved Coastal Zone Management Plan".

This chapter will assist in evaluating criteria #7 by describing the commercial, recreational, and subsistence fisheries in the Cook Inlet/Shelikof Strait Planning Area, and discussing the potential impacts exploratory drilling may impose on these activities.

The Kenai Peninsula and Kodiak Island Coastal Zone Management Plans both include provisions for the continuance of subsistence resources and harvesting within their jurisdiction, therefore; discussions on subsistence harvests in the chapter are applicable to considerations of criteria #8.

7.1 COMMERCIAL HARVESTS

The Cook Inlet and Shelikof Strait area sustains several commercially important fisheries. The most important fisheries include salmon, groundfish, halibut, herring, and crabs. Other minor fisheries include invertebrates, such as shrimp, clams and scallops.

In 1985, the Fisheries Oceanography Coordinated Investigations (FOCI) program of applied research was implemented as a long-term cooperative effort between scientists at the Pacific Marine Environmental Laboratory and the Alaska Fisheries Science Center. The goal of FOCI is to gain an understanding of the biotic and abiotic factors influencing recruitment of various commercially valuable fish and shellfish stocks in Alaskan waters. Most of the FOCI research to date has been concentrated on walleye pollock spawning in Shelikof Strait.

7.1.1 Salmon

The State of Alaska manages the salmon fishery, which is the largest fishery in terms of pounds harvested and employment. Five species of salmon are commercially harvested in Cook Inlet and Shelikof Strait: pink, sockeye, chinook, coho, and chum [scientific names for harvested species are provided in Appendix B]. In 1986, 9.6 million salmon were harvested in the upper and lower Cook Inlet management areas with an ex-vessel value of 47.6 million dollars (Kenai Peninsula Borough 1990). Pink salmon comprise the largest proportion of the salmon harvest in lower Cook Inlet and outer coasts, with yields accounting for 79% of the total salmon harvest.

Adult salmon are present in nearshore and estuarine waters adjacent to the Kenai Peninsula from late April to early November and begin migrations to freshwater from May to November. Juvenile salmon emerge from bottom substrates from April until June. Pink and chum salmon immediately move downstream to estuarine areas while other species remain in freshwater for one to four years before moving to marine waters. Chum salmon remain within thirty miles of the shore during July through September and young chinook remain in nearshore water during their first year at sea (see Table 7-1 for life history summary).

Commercial harvests in Cook Inlet capture fish primary with gillnets. Set gill nets are used throughout the upper Cook Inlet, while drift gill nets are used primarily in the offshore areas of middle Cook Inlet. In lower Cook Inlet, seine gear and set gill nets are used. In recent years, the Nanwalek/Port Graham area on the tip of the Kenai Peninsula has been closed to commercial set gill net fishing due to a significant decrease in the local sockeye salmon population (Kenai Peninsula Borough 1990).

7.1.2 Groundfish

The commercial fishery for groundfish consists chiefly of walleye pollock, Pacific cod, rockfish, flounder, and sablefish. The fishing methods used in Cook Inlet are primarily longline and jig gear, while trawls are the preferred harvest method in Shelikof Strait.

TABLE 7-1. LIFE HISTORY DATA FOR THE FIVE SPECIES OF ALASKA SALMON					
	Species				
	Pink	Chum	Coho	Sockeye	Chinook
Number of eggs per female	2,000	3,000	3,500	3,700	4,800
Spawning season	mid-Jun to Oct	Jul-Nov	Jul-Dec	June-Nov	mid-May to mid-Dec
Time spent in freshwater	several days to several weeks	less than 1 month	1-2 years	1-4 years	3-12 months, 1-2 years
Out-migration of smolts	Feb-Apr	May-Sept	Feb to mid-Jul	May-Sept	Mar-Aug
Length of ocean phase (years)	1 and 1/3	1/2 to 5	1 to 2	1/2 to 4	1 to 5
Age at maturity (years)	2	2 to 6	2 to 4	3 to 7	2 to 8
Major spawning areas	intertidal and short streams	river-lake systems	short coastal streams and intertidal	river-lake systems	large rivers and tributaries

Source: U.S. DOI 1984, p. III-20.

*7.1.2.1 **Walleye Pollock.*** Pollock from Cook Inlet and Shelikof Strait, and Pacific cod from Shelikof Strait comprise the majority of groundfish harvested in the sale area. In Cook Inlet alone, 5,359 metric tons (11,814,573 lbs) of pollock were harvested in 1986 (Kenai Peninsula Borough 1990). From 1981 to 1988 an intense fishery existed in Shelikof Strait for spawning walleye pollock although the harvest has been severely restricted since 1986 due to reduced population abundance. The Shelikof Strait harvest peaked in 1984 at approximately 31 x 10^4 metric tons (683 x 10^6 lbs) with most of the fishing effort conducted prior to and during spawning (Kendall and Nakatani 1992).

A joint venture fishery for walleye pollock among the United States and foreign vessels has operated for several years in the Shelikof Strait area. This arrangement has arisen primarily because domestic fisheries are interested in fish harvests, but lack sufficient fish processing capabilities. U.S. vessels harvest the bottomfish and sell the catch to foreign processing vessels. The foreign fishing fleets operating within 200 miles (322 km) of the coasts are restricted to groundfish by the Magnuson Fishery Conservation and Management Act of 1976 (U.S. DOI 1984).

7.1.3 Other Fisheries

The Pacific halibut fishery is managed by the International Pacific Halibut Commission. The main fishing areas include Anchor Point, the area around the tip of the Kenai Peninsula, near the Barren Islands, the east side of Shelikof Strait, and the Wide Bay area of Shelikof Strait (U.S. DOI 1984). Halibut is harvested primarily by longline gear, although occasionally hand line gear is employed. In 1986, 6,486 metric tons (14.3 x 10^6 lbs) of halibut were harvested in Kenai Peninsula ports with an ex-vessel value of 19.8 million dollars. The halibut season generally consists of two short openings in late April and late May or June (Kenai Peninsula Borough 1990).

The herring sac-roe fishery is generally active during the fall and winter months. Fish are harvested primarily from Prince William Sound and around Kodiak Island. Purse seine is the preferred harvest method.

The commercial crab fishery currently consists of two species: Tanner and Dungeness crabs. The Tanner crab season usually runs from January until March. The greatest number of Tanner crabs are harvested from Kachemak Bay, the western portion of lower Cook Inlet, the northern portion of Shelikof Strait, and the eastern side of Shelikof Strait. The Tanner crab fishery has been closed for the past year in Shelikof Strait due to a depressed breeding stock (Spallinger, A., 27 July 1993, personal communication). In 1987, approximately 1,111 metric tons (2,450,000 lbs) of Tanner crab were harvested in lower Cook Inlet.

The Dungeness crab season remains open most of the year, except for a few regulated closures. Approximately 256 metric tons (563,722 lbs) of Dungeness crab were harvested in lower Cook Inlet in 1986.

The king crab fishery has been steadily declining since 1980; therefore, there has not been a commercial opening in the Cook Inlet area and Shelikof Strait since 1983 (Brady, J., Spallinger, A., 27 July 1993, personal communication).

Additional minor fisheries include shrimp, clams, and scallops. Four species of shrimp are harvested in lower Cook Inlet and Shelikof Strait with pots and/or trawl gear. Pink shrimp comprise the majority of the harvest. There are early spring, summer, and winter harvesting seasons for specific gear types. During the 1986/87 season, approximately 364 metric tons (801,821 lbs) of shrimp were harvested in lower Cook Inlet (Kenai Peninsula Borough 1990). Both razor and hardshell clams are harvested by rake and shovel on the beaches in Kachemak Bay and the west side of Cook Inlet. Weathervane scallops are harvested in the lower Cook Inlet primarily in Kamishak Bay between August and October.

7.2 RECREATIONAL HARVESTS

Recreational fishing in the Lease Sale area is enjoyed by Alaskan residents as well as non-residents. In 1991, the recreational fishing effort in the Cook Inlet and Shelikof Strait area was estimated to be 1,269,889 angler days (52% of the state's total sport fishing effort). This effort resulted in the harvest of 539,593 fish (Mills 1992). The predominant species harvested are salmon, trout, Dolly Varden, halibut, and Arctic grayling (Table 7-2). Other species commonly harvested in seawater include herring, cod, clams (razor and steamer), crab, and shrimp.

TABLE 7-2. ALASKA RECREATIONAL FISH AND SHELLFISH HARVESTS IN 1991 (NUMBERS)

	Species							
Area Fished	Salmon: Pink Sockeye Chinook	Salmon: Coho Chum	Trout[a]	Dolly Varden Arctic Char	Arctic Grayling	Halibut	Other[b]	Shellfish
East Susitna River Drainage	13,981	21,429	8,580	2,140	3,875	0	626	0
W. Cook Inlet-W. Susitna River Drainings	27,272	29,743	5,343	2,809	3,393	1,576	12,103	27,658
Kenai Peninsula[c]	22,511	40,781	12,168	2,241	1,472	160,888	0,995	1,179,802
Kodiak	19,516	19,023	1,623	12,794	98	12,089	2,995	119
Naknek River Drainage-Alaska Peninsula	16,662	6,632	1,936	10,364	649	5,199	15,991	0

[a] Includes steelhead, rainbow, cutthroat, and lake trout.

[b] Includes burbot, smelt, and whitefish.

[c] Includes waters contiguous to the Kenai Peninsula, including waters around Kalgin Island (excludes Kenai River drainages).

Source: Mills (1992).

The Kenai River, located in upper Cook Inlet, is the location where the largest sportfish harvest of chinook salmon occurs. This river also contains an indigenous population of rainbow trout. Other waters for chinook sportfishing are located on both sides of lower Cook Inlet.

Homer Spit, located near the southern tip of the Kenai Peninsula, is the site of an experimental enhancement program involving chinook and coho salmon smolt and pink salmon fry releases. The primary goal of the program is to fulfill the summer demand for more sportfishing opportunities in the Kachemak Bay area (Kenai Peninsula Borough 1990).

The recreational halibut season occurs from February 1 to December 31 by regulation; however, due to weather constraints the majority of halibut harvested from the Kenai Peninsula are taken from late April through early September.

7.3 SUBSISTENCE HARVESTS

Subsistence resources are important to the economy and culture of many communities, especially in for the residents of Nanwalek, Port Graham, Tyonek, Seldovia, and other rural areas with limited road access on the Kenai Peninsula (Figure 7-1). Subsistence harvests in several of these communities comprise a major proportion of the daily diets for these residents (i.e., Nanwalek, Port Graham, and Tyonek).

Only residents of Nanwalek, Port Graham, Tyonek, and Seldovia are entitled by the Alaska Boards of Fisheries and Game to participate in subsistence fishing and hunting in their areas and a permit must be issued prior to harvesting. Legal gear for subsistence harvest of salmon and herring is set gill nets, handlines for halibut, and both handlines and skates for other bottomfish (Kenai Peninsula Borough 1990).

Subsistence harvesting generally occurs in rivers and nearshore waters on a year round basis for shellfish and other marine invertebrates, and seasonally for salmon and halibut. Species harvested include salmon, halibut, cod, rockfish, clams, crabs, and various other fish and invertebrates. The proportion of each species harvested varies among households and between communities (Tables 7-3 and 7-4). Marine mammals are allowed to be used as a subsistence resource by regulation and the numbers taken vary substantially among communities.

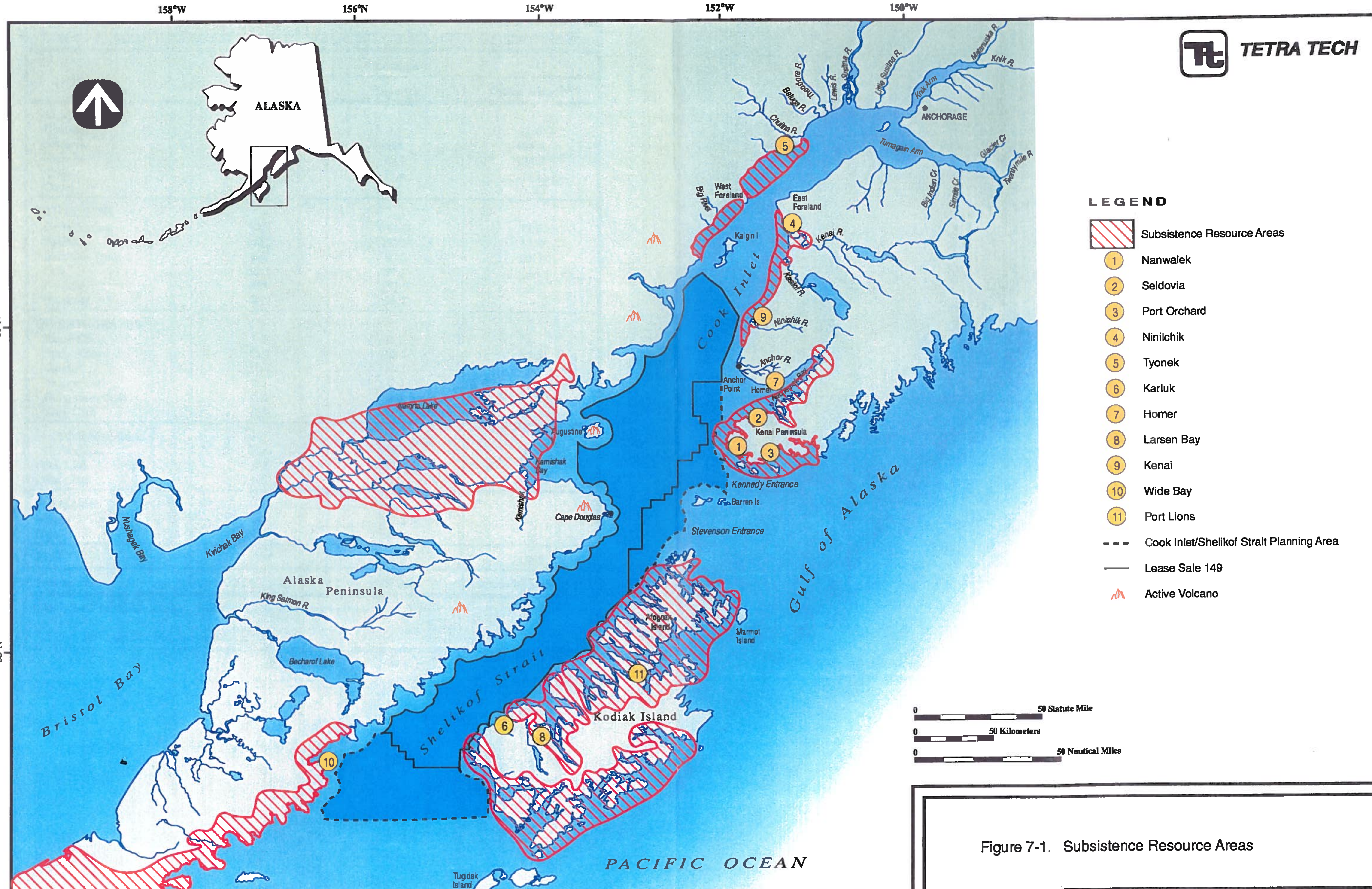


Figure 7-1. Subsistence Resource Areas

TABLE 7-3. MEAN HOUSEHOLD SUBSISTENCE HARVEST FOR SELECTED SPECIES (POUNDS)			
	Location		
Resource	Port Graham	Nanwalek	Kodiak Island[a,b]
SALMON			
Chinook	14.7	2.7	21.6
Sockeye	41.3	193	424.4
Pink	66	93.9	134.7
Coho	125.2	78.6	123
Chum	55.4	8.0	7.2
OTHER FISH			
Dolly Varden	10.2	144.9	73.6
Halibit	112.8	127.3	17.9
Rainbow Trout	0.6	10.0	20.4
Cod	32.7	55.1	--
Rockfish	36.9	121.2	--
Flounder	40.7	35.2	--
INVERTEBRATES			
Razor Clam	1.3	0.1	--
Butter Clam	13.3	15.6	15.5
Chiton	14.5	35.3	--
Tanner Crab	0.1	0.0	11.2
Dungeness Crab	0.6	0.0	20.7
King Crab	0.0	0.0	28.3
MARINE MAMMALS			
Harbor Seal	25.0	36.4	3.9
Sea Lion	7.4	42.4	1.9
Sea Otter	0.0	0.0	--
BIG GAME			
Moose	9.3	15.2	--
Deer	1.6	6.6	--
Year:	1987	1987	1983
Source:	KPB 1990	KPB 1990	Schroeder et al. 1987

[a] Includes Karluk, Larsen Bay, and Port Lions communities only.

[b] Values listed are numbers harvested.

TABLE 7-4. RESOURCE USES FOR SIX SPECIES, 1982.

Location	Chinook Salmon				Sockeye Salmon				Coho Salmon			
	% Household Used	% Household Harvested	Mean* Pounds Used	Mean* Pounds Harvested	% Household Used	% Household Harvested	Mean* Pounds Used	Mean* Pounds Harvested	% Household Used	% Household Harvested	Mean* Pounds Used	Mean* Pounds Harvested
Kenai (N=197)	41	30	12	10	59	46	17	15	64	45	21	18
Ninilchik (N=24)	63	50	33	22	50	42	20	8	54	33	13	13
Homer City (N=97)	47	30	27	14	46	21	16	10	62	31	18	13
Homer area (N=76)	53	39	43	33	43	25	12	8	70	52	38	33
Seldovia (N=35)	49	11	16	6	66	26	27	16	69	40	27	23

Location	Halibut				Clams				Moose			
	% Household Used	% Household Harvested	Mean* Pounds Used	Mean* Pounds Harvested	% Household Used	% Household Harvested	Mean* Pounds Used	Mean* Pounds Harvested	% Household Used	% Household Harvested	Mean* Pounds Used	Mean* Pounds Harvested
Kenai (N=197)	70	28	41.0	28.3	35	26	8	7	24	4	21.2	10
Ninilchik (N=24)	88	42	57.2	37.4	83	83	34	34	67	8	90.9	46.9
Homer City (N=97)	90	50	107.3	83	54	42	16	16	38	13	68.9	51.5
Homer area (N=76)	89	51	87	69	51	44	11	11	43	9	84	44
Seldovia (N=35)	97	34	60	28	89	69	27	22	40	3	18	13

*Household mean for sampled households.
Source: Reed 1985 (cited in KPB 1990).

A subsistence study of Nanwalek and Port Graham harvests determined that in the second year following the Exxon Valdez spill in March of 1989, subsistence harvests remained below pre-spill levels, primarily due to concerns about hydrocarbon contamination (Fall 1991). The extent of the Exxon Valdez oil spill in the Lease Sale area is depicted in Figure 7-2.

Waterfowl; particularly the year round residents such as white-winged scoters, mallards, and goldeneyes, are harvested in winter months in Kachemak Bay. Other geese and ducks are taken in spring and fall when they are in coastline areas and rivers and lakes.

Moose provide the primary big game meat for all of the subsistence communities along Cook Inlet and the Kenai Peninsula. As the possibility of drilling discharges affecting moose populations is remote, they will not be discussed here.

7.4 EFFECTS OF DRILLING DISCHARGE ON HARVEST QUANTITY

7.4.1 Recreational and Subsistence Fisheries

Exploratory drilling activities in the Lease Sale area are not expected to adversely affect or interfere with recreational or subsistence fisheries. The majority of recreational and subsistence fishing occurs in nearshore waters outside of the Lease Sale area and exposure of harvested species (adults) to drilling discharges are expected to be minimal.

The larvae and juveniles of several harvested species occur in the Lease Sale area and may be exposed to drilling discharges. The impacts of any exposure will depend on the exposure duration, frequency, and site-specific characteristics. Therefore, it is not possible to state with certainty what impact drilling discharges may have on larval and juvenile stages. Nevertheless, given the high dilutions expected for discharges in the Lease Sale area, and the relatively small area expected to be impacted by drilling discharges, impacts to populations are expected to be negligible.

7.4.2 Commercial Fisheries

Drilling activities may potentially impact commercial fisheries due to restricted access to fishing grounds, and/or impacts to fish stocks.

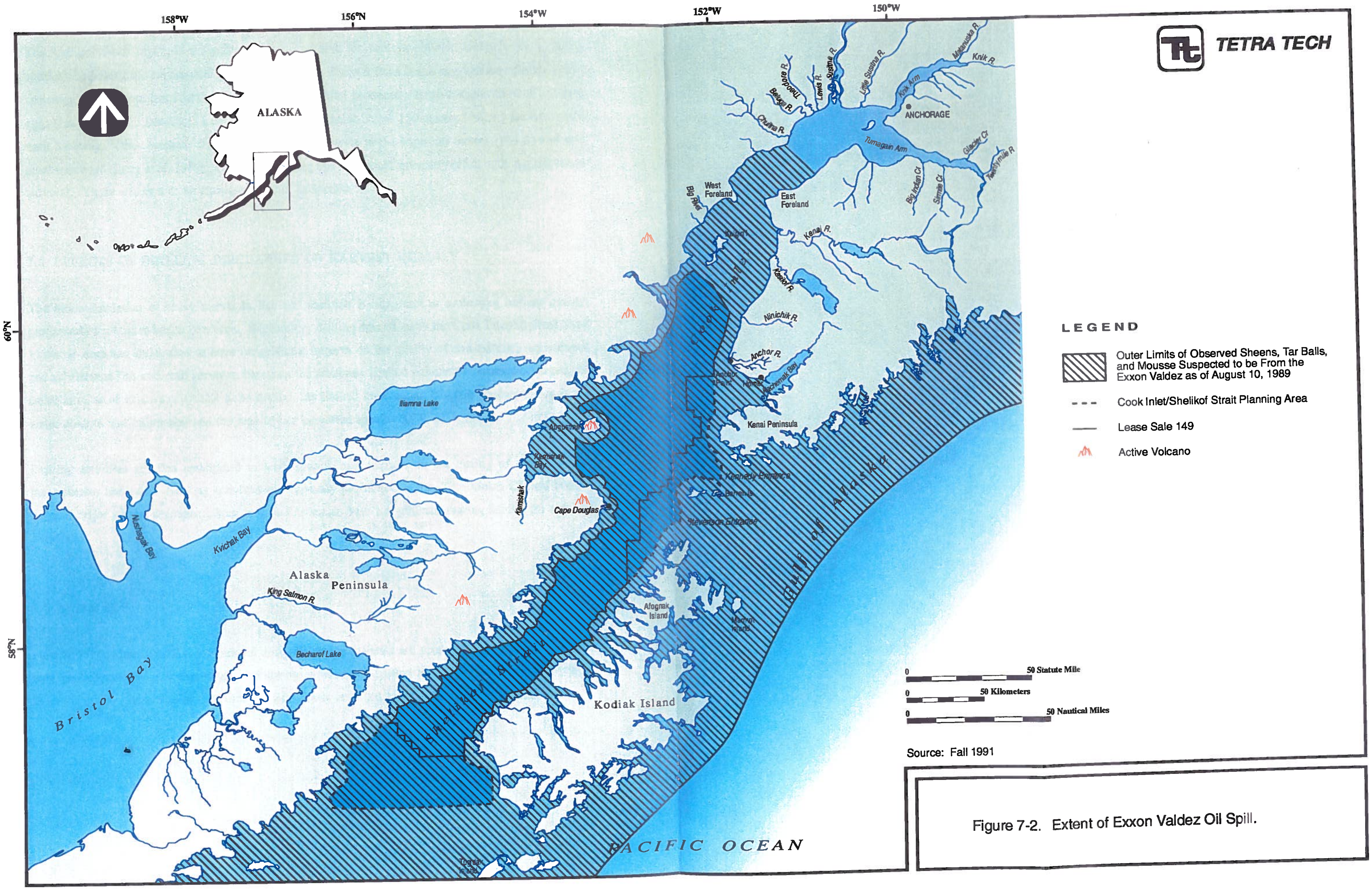


Figure 7-2. Extent of Exxon Valdez Oil Spill.

The Shelikof Strait region is a significant spawning area for walleye pollock, which is the principal species comprising the commercial groundfish fishery. Pollock form dense aggregations during a brief spawning period from late March to mid-April. Spawning produces a large concentration of demersal eggs (ranging from 3,004-23,171 m^2) that generally remains below 150 meters (492 ft) for two weeks until hatching. Once hatched, the larvae tend to concentrate in the upper 50 meters (164 ft) and drift southwestward (Incze et al. 1989). Discharges during this time could adversely effect both egg and larvae survival. These effects will be discussed further in Section 5.

7.5 EFFECTS OF DRILLING DISCHARGES ON HARVEST QUALITY

The bioaccumulation of heavy metals in fish and shellfish is important in evaluating harvest quality, particularly for human health concerns. Exploratory drilling operations in the Cook Inlet/Shelikof Strait Planning Area are anticipated to have insignificant impacts on the quality of commercial, recreational, and subsistence fish and crab harvests, based on the relatively limited volume of wastes discharged, the small number of exploratory wells to be drilled, the limited areal extent of toxic concentrations in the water column and sediments, and the mobility of harvested species (U.S. EPA 1993).

Drilling activities are also anticipated to have insignificant impacts on the quality of sessile marine invertebrates harvested. Drilling activities are currently prohibited in the Clam Gulch Critical Habitat Area, a major habitat for razor clams, and in Kachemak Bay, a significant rearing habitat for fish and shellfish.

7.6 SUMMARY

Nearshore locations used for recreational and subsistence fisheries are predominantly outside areas that may be impacted by activities conducted during exploratory drilling in the Cook Inlet/Shelikof Strait Planning Area. Thus, the impacts to these fisheries is expected to be minimal or non-existent.

Exploratory operations within the area may potentially adversely impact the quantity of fish commercially harvested if discharges occur in the vicinity of critical spawning habitat. The likelihood of impacts to commercially harvested species is strongly dependent on the timing and location of exploratory drilling discharges.

8.0 COASTAL ZONE MANAGEMENT AND SPECIAL AQUATIC SITES

The determination of "unreasonable degradation" of the marine environment is to be made based on consideration of the 10 criteria listed in chapter 1.0. This chapter provides information pertinent to consideration of the two *ocean discharge* criteria shown below:

- **Criteria #8**: "Any applicable requirements of an approved Coastal Zone Management Plan"

- **Criteria #5**: "The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs".

8.1 COASTAL ZONE MANAGEMENT

8.1.1 Requirements of Coastal Zone Management Act

The Coastal Zone Management Act requires that states make consistency determinations for any federally licensed or permitted activity affecting the coastal zone of a state with an approved Coastal Zone Management Program (CZMP) (16 USC Sec. 1456(c)(A) Subpart D). Under the Act, applicants for federal licenses and permits must submit a certification to the Alaska Coastal Policy Council (ACPC) that the proposed activity complies with the state's approved CZMP. The state then has the responsibility to either concur with or object to the consistency determination. For general NPDES permits, U.S. EPA is considered an applicant submitting the general permit to the state for a consistency determination.

Consistency certifications are required to include the following information (15 CFR 930.58):

- A detailed description of the proposed activity and its associated facilities.

- A brief assessment relating the probable coastal zone effects of the proposal and its associated facilities to relevant elements of the CZMP.

- A brief set of findings indicating that the proposed activity, its associated facilities, and their effects are consistent with relevant provisions of the CZMP.

- Any other information required by the state.

8.1.2 Relevance of Requirements

Consistency determinations are required if a federally licensed or permitted activity "affects" the coastal zone. Discharges of drilling muds and cuttings during exploratory oil and gas activities in the Shelikof Strait and Cook Inlet areas of Lease Sale 149 will occur in state waters inside the 5-km (3-mi) territorial sea limit. These discharges have the potential to affect Alaska's coastal waters, therefore, a consistency assessment has been prepared.

8.1.3 Status of Coastal Zone Management Planning

The Alaskan Coastal Management Program (ACMP) was approved by the U.S. Department of Commerce in 1979. The state coastal management policies and guidelines included in the ACMP are intended to be refined by local districts preparing district Coastal Management Programs(CMPs). Completed district CMPs must be approved first by the Alaska Coastal Policy Council and then by the Department of Commerce, either as a routine program implementation or as an amendment to the ACMP. Once approved by the Department of Commerce, the district CMPs become the basis for federal consistency determinations. There are three district CMPs that are applicable within state waters of the Cook Inlet and Shelikof Strait sale area (Figure 8-1):

- Kenai Peninsula Borough CMP
- Kodiak Island Borough CMP
- Lake and Peninsula Borough CMP.

Figure 8-1 shows all three boroughs have boundaries which extend beyond the 3-mile limit of state jurisdiction. Although the State has absolute authority only for waters extending to the 3-mile limit, the CMPs are applicable for all land and water activities which may affect the boroughs' coastal areas or resources (Vernon, G., 6 August 1993; Freed, L., 11 August 1993, personal communication).

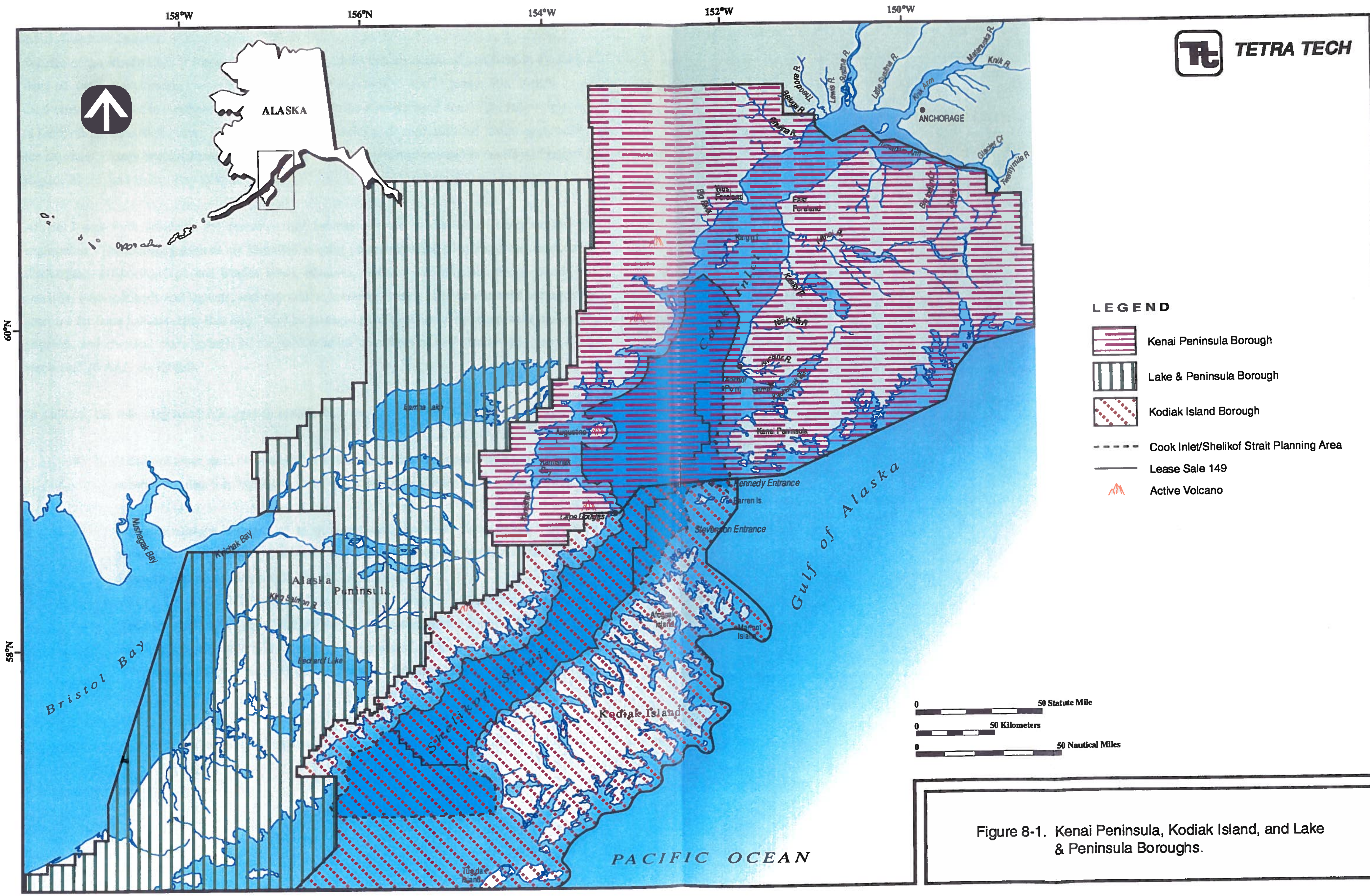


Figure 8-1. Kenai Peninsula, Kodiak Island, and Lake & Peninsula Boroughs.

8.1.4 Relevant Policies

Policies of the Alaska Coastal Management Program (ACMP) that are potentially relevant to discharges from oil and gas exploration are set forth in the ACMP standards (6 AAC Chapter 80). Article 2 sets forth standards related to a number of uses and activities in the Alaska coastal zone. The following policy is set forth for subsistence uses: "Districts and state agencies shall recognize and assure opportunities for subsistence usage of coastal areas and resources." This policy is implemented in the Kenai Peninsula, Kodiak Island, and Bristol Bay District CMPs.

Article 3 sets forth standards for resources and habitats relevant to discharges from oil and gas exploration. The following habitats are identified as being potentially affected by petroleum exploration discharges: offshore pelagic and benthic areas, estuaries, wetlands and tideflats, rocky islands and seacliffs, barrier islands and lagoons, and exposed high energy coasts. The fundamental management standard for these habitats states that they "must be managed so as to maintain or enhance the biological, physical, and chemical characteristics of the habitat which contribute to its capacity to support living resources" (6 AAC 80.130[b]).

In addition, the following standards apply to specific habitats:

- "Offshore areas must be managed as a fisheries conservation zone so as to maintain or enhance the state's sport, commercial, and subsistence fishery" (6 AAC 80.130[c][1]).

- Estuaries must be managed so as to assure adequate water flow, natural circulation patterns, nutrients, and oxygen levels, and avoid the discharge of toxic wastes, silt, and destruction of productive habitat (6 AAC 80.130[c][2]).

- Wetlands and tideflats must be managed so as to assure adequate water flow, nutrients, and oxygen levels, and avoid adverse effects on natural drainage patterns, the destruction of important habitat, and the discharge of toxic substances (6 AAC 80.130[c][3]).

- Rocky islands and seacliffs must be managed so as to avoid the harassment of wildlife, destruction of important habitat, and the introduction of competing or destructive species and predators (6 AAC 80.130[c][4]).

- Barrier islands and lagoons must be managed so as to maintain adequate flows of sediments, detritus, and water, avoid the alteration or redirection of wave energy which would lead to the filling in of lagoons or the erosion of barrier islands, and discourage activities which would decrease the use of barrier islands by coastal species, including polar bears and nesting birds (6 AAC 80.130[c][5]).

- High energy coasts must be managed by assuring the adequate mix and transport of sediment and nutrients and avoiding redirection of transport processes and wave energy (6 AAC 80.130[c][6])."

8.2 DISTRICT COASTAL MANAGEMENT PLANS

8.2.1 Kenai Peninsula Borough

The Kenai Peninsula Borough district CMP was federally approved by the Department of Commerce in June 1990 and includes state coastal waters bordered on the east by the Gulf of Alaska and Prince William Sound and on the north by Turnagain Arm, upper Cook Inlet and the divide of the Susitna watershed. To the west, state coastal waters include upper Cook Inlet south to Cape Douglas and the north end of Shelikof Strait (Kenai Peninsula Borough 1990).

The Kenai Peninsula Borough CMP incorporates the state policies and adds the following policies under Kenai Peninsula Borough CMP, Section 5.0 Energy and industrial development. The borough's program provides for a basis for the determination of whether various uses are proper or improper with respect to the policies outlined below.

- "Site facilities so as to minimize the probability, along shipping routes, of spills or other forms of contamination which would affect fishing grounds, spawning grounds, and other biologically productive or vulnerable habitats, including marine mammal rookeries and hauling out grounds and waterfowl nesting areas" (Kenai Peninsula Borough CMP 5.0[b][11]).

- "Site facilities so that design and construction of those facilities and support infrastructure in coastal areas of Alaska will allow for the free passage and movement of fish and wildlife with due consideration for historic migratory patterns and so that areas of particular scenic, recreational, environmental, or culture value will be protected" (Kenai Peninsula Borough CMP 5.0[b][12]).

- "Geophysical surveys will, to the extent feasible and prudent, be located, designed, and conducted in a manner so as to avoid disturbances to fish and wildlife populations, habitats, and harvests. Seasonal restrictions, restrictions on the use of explosives, or restrictions relating to the type of transportation utilized in such operations will be included as necessary to mitigate potential adverse impacts" (Kenai Peninsula Borough CMP 5.9[a]).

- "Vessels engaged in offshore geophysical exploration will conduct their operations to avoid significant interference with commercial fishing activities" (Kenai Peninsula Borough CMP 5.9[c]).

Section 11.0, "Subsistence", of the Kenai Peninsula Borough CMP includes the following relevant items to ensure opportunities for subsistence usage.

- "Projects in areas traditionally used for subsistence shall be located, designed, constructed, and operated to minimize adverse impacts to subsistence resources and activities" (Kenai Peninsula Borough CMP 11.2).

- "Land and water use plans for public land and waters surrounding the communities of English Bay, Port Graham, Seldovia, and Tyonek shall avoid or minimize impacts to subsistence resources and activities" (Kenai Peninsula Borough CMP 11.3).

Section 12.0, "Fish and Wildlife Habitat", of the Kenai Peninsula Borough CMP includes the following relevant items regarding biota and habitat.

- "To protect fish, sensitive marine mammals, and other aquatic fauna, explosives shall not be detonated within, beneath, or adjacent to marine, estuarine, or fresh waters that support fish and wildlife during periods when fish or marine mammals are present unless the detonation of the explosives produces an instantaneous pressure rise in the water body of no more than 2.5 psi or unless the water body, including its substrate, is frozen" (Kenai Peninsula Borough CMP 12.6).

- "Seabird colony sites and haul-outs and rookeries used by sea lions and harbor seals shall not be physically altered or disturbed by structures or activities in a manner that would preclude or interfere with continued use of these sites. To the extent feasible and prudent, development structures and facilities with a high level of noise, acoustical or visual disturbance shall maintain a one-half mile buffer from identified use areas for sea lions, harbor seals, and marine birds during periods when these species are present" (Kenai Peninsula Borough CMP 12.7).

- "Uses and activities within or adjacent to coastal waters shall not interfere with migration or feeding of whales. Interference refers to conduct or activities that disrupt an animal's normal behavior or cause a significant change in the activity of the affected animal" (Kenai Peninsula Borough CMP 12.8).

8.2.2 Kodiak Island Borough CMP

The Kodiak Island Borough district CMP is bordered on the south by Chirikof Island and east by the Kodiak Island three mile coastal zone. The northern boundary is south of Chugach Island and continues southwest to Shelikof Strait, south to the Semidi Islands and southeast to Chirikof Island. The Kodiak Island Borough CMP was federally approved by the Department of Commerce in January 1984 (Kodiak Island Borough 1984).

The Kodiak Island Borough CMP also incorporates the state policies and contains the following policies under Kodiak Island Borough CMP 5.3.2 Specific use policies.

- "Sites shall be selected where water discharges and oil spills can be contained and damage to the environment minimized" (Kodiak Island Borough CMP, Energy Facilities, 5.3.2[8]).

- "Effluent discharge from energy facilities shall be located where currents can disperse effluents and where the cumulative impact does not violate state and federal water quality standards" (Kodiak Island Borough CMP, Energy Facilities, 5.3.2[10]).

- "Habitats shall be managed in accordance with State and federal laws to ensure that the subsistence use of resources is a primary use" (Kodiak Island Borough CMP, Subsistence, 5.3.2[2]).

- "The discharge of wastewater and toxic wastes into Kodiak Island Borough waters shall be limited to areas with adequate flushing action and in accordance with State of Alaska regulations. Discharge shall not be in amounts to render such water unsuitable for fish survival, industrial cooling, and industrial process watering supply purposes" (Kodiak Island Borough CMP, Air and Water Quality, 5.3.2[3]).

8.2.3 Lake and Peninsula Borough CMP

The Lake and Peninsula Borough was created in April of 1989. It includes state coastal waters in the lower Shelikof Strait and is currently utilizing the Bristol Bay Coastal Resource Service Area CMP, which received federal approval in 1987, until the Lake and Peninsula Borough CMP is completed. The draft CMP has an expected completion date of July 1993 (Vernon, G., 13 July 1993, personal communication).

The Bristol Bay CMP also incorporates the state policies and contains the following additional policies under Bristol Bay Coastal Resource Service Area CMP Energy Facilities.

- "Geophysical surveys in fresh and marine waters will require the use of energy sources such as airguns, gas exploders, or other sources that have been demonstrated to be harmless to fish and wildlife. Blasting for other purposes other than geophysical surveys..." (Bristol Bay CRSA CMP 4.2).

- "Vessels engaged in offshore geophysical exploration will conduct their operations to avoid significant interference with commercial fishing activities" (Bristol Bay CRSA CMP 4.3).

- "Critical fish and wildlife habitat will be leased for energy development only if it is compatible, or, through the use of mitigating measures, can be made compatible, with the maintenance of such populations and habitat. Lease free buffer zone in or adjacent to critical habitat will be an alternative evaluated when an area is to be offered for lease" (Bristol Bat CRSA CMP 4.4).

- "Energy facilities will be sited, designed, constructed, and maintained so as to avoid significant adverse impacts to fish and wildlife populations. Oil and gas exploration and production wells will be located so as to avoid interfering with commercial fishing and subsistence harvests within the Bristol Bay Fisheries Reserve.... In all other offshore areas, such interference will be avoided to the extent feasible and prudent. In addition, measures to prevent drilling wastes, oil spills, and other toxic or hazardous materials from contaminating drinking water supplies and fish, waterfowl, and shorebird habitat will be utilized" (Bristol Bay CRSA CMP 4.5).

The following policies are included under "Habitats" and "Air, Land, and Water Quality" respectively:

- "Maintenance and enhancement of fisheries will be given the highest priority when evaluating projects which may impact fish spawning, migration, rearing, and over wintering areas. Shorelines that have banks, beaches, and beds critical to fish populations will be maintained in a productive natural condition" (Bristol Bay CRSA CMP 10.1).

- "The quality of fish-bearing waters must, at a minimum, be maintained at a level which will ensure the continued health and propagation of fish populations. A use or activity which cannot be conducted in such a manner will not be permitted" (Bristol Bay CRSA CMP 11.1).

8.3 CONSISTENCY ASSESSMENT

The ODCE for Sale 60 (U.S. EPA 1983, pp. 125-126) concluded that "waste discharges associated with oil and gas exploration in lower Cook Inlet and Shelikof Strait comply with and will be conducted in a manner consistent with relevant Alaska Coastal Management Program policies". The consistency assessment for the present ODCE is based upon the following findings:

- Based on the analyses in Section 7.0, opportunities for subsistence usage of coastal resources are unlikely to be threatened by discharges of drilling muds and cuttings.

- Coastal habitats will be managed to maintain the biological, physical, and chemical characteristics of the habitats which contribute to their capacity to support living resources. This finding is based on analyses in Sections 3.0 and 5.0 indicating that coastal habitats are unlikely to experience significant adverse impacts from discharges of drilling muds and cuttings.

- Offshore areas will be managed to maintain sport, commercial, and subsistence fisheries. This finding is based on analyses in Section 7.0 indicating that sport, commercial, and subsistence harvests are unlikely to experience degradation from discharges of drilling muds and cuttings.

- Estuaries, wetlands, and tideflats will not be affected adversely by discharges. This finding is based on analyses in Sections 3.0 and 9.0 indicating that toxic substances in drilling muds and cuttings will be rapidly diluted and are likely to be undetectable in the vicinity of these coastal habitats.

- Mixing and transport processes of high energy coasts will not be affected by discharges of drilling muds and cuttings.

8.4 SPECIAL AQUATIC SITES

Refer to Figure 8-2 for exact locations of the sites listed below.

8.4.1 Marine Sanctuaries

No marine sanctuaries, as defined by 40 CFR 125.122 (5), are known to be located in the Lease Sale area. However, designated islands surrounding Kodiak and Afognak islands, the Barren Islands, designated islands and inlets on the south side of the Alaska Peninsula, Augustine Island, and the Semidi Islands are located adjacent to the sale area, and comprise part of the Alaska Maritime National Wildlife Refuge (Figure 8-2).

8.4.2 Critical Habitat

Approximately 215,000 acres of tidelands and submerged lands in Kachemak Bay were designated as Critical Habitat Area (CHA) in 1974 in order to protect crucial fish, shellfish, crab and wildlife spawning and habitat areas.

The Clam Gulch State CHA established in 1976 is located south of Kasilof on the Kenai Peninsula comprises approximately 30,080 acres of tide and submerged lands above the minus five foot elevation due to important razor clam habitat.

Established in 1972, the Kalgin Island CHA encompasses approximately 2,880 acres of uplands, tidelands, and submerged lands due to vital tidal marsh and migrating waterfowl areas.

The Fox River Flats CHA instituted in 1972 is located on the east end of Kachemak Bay and contains approximately 5,750 acres of uplands, tidelands, and submerged lands. This area is critical shorebird and waterfowl habitat.

The Redoubt Bay State CHA was founded in 1989 to ensure the protection and enhancement of fish and wildlife, particularly Tule geese. State lands, tidelands, and submerged lands are included in this area.

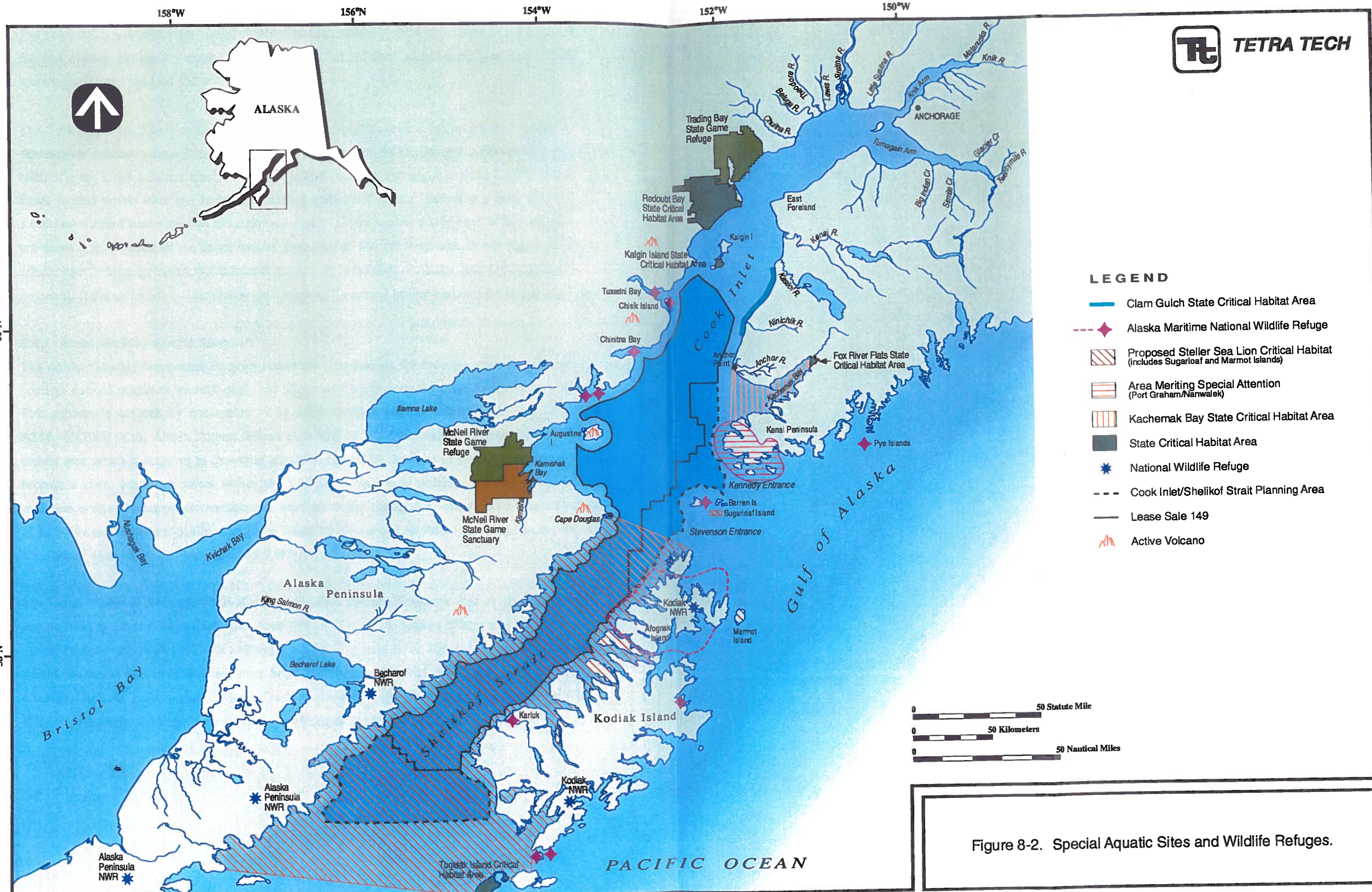


Figure 8-2. Special Aquatic Sites and Wildlife Refuges.

The Tugidak CHA located south of Kodiak Island was established in 1988 in order to protect and enhance fish and wildlife, particularly marine mammals, birds, fish and shellfish and comprises state land above mean high tide and the land and water in the lagoon.

The National Marine Fisheries Service has proposed to designate critical habitat for the Steller sea lion *(Eumetopias jubatus)* pursuant to the Endangered Species Act (ESA). Specific proposal sites directly relating to the Lease Sale area are: 1) all Steller sea lion rookeries and major haulouts (>200 Steller sea lions) located within state and Federally managed waters off Alaska, including a zone that extends 3,000 feet seaward from rookeries and major haulouts in Alaska located east of 144° W longitude, or 20-nm seaward from rookeries and major haulout sites west of 144° W longitude, 2) one aquatic zone for critical aquatic foraging habitat that is located exclusively in the Gulf of Alaska (Shelikof Strait) has been proposed. Refer to Section 6.0 for further discussion on the critical habitat proposal for Steller sea lions.

8.4.3 Areas Meriting Special Attention

The Alaska Coastal Management Program authorizes a mechanism for focusing attention to areas of a borough deemed critical to borough needs and where conflicts or potential conflicts are likely to occur. This process is initiated by nomination of an Area Meriting Special Attention (AMSA). Section AS46.40.210(1) of the Alaska Statutes defines an AMSA as: "a delineated geographic area within the coastal area which is sensitive to change or alteration and which, because of plans or commitments or because a claim on the resources within the area delineated would preclude subsequent use of the resources to a conflicting or incompatible use, warrants special management attention, or which, because of its value to the general public, should be identified for current or future planning, protection, or acquisition" (Kodiak Island Borough CMP 7.0[7-1]).

The Kenai Peninsula Borough CMP identified the Port Graham/Nanwalek area as an "AMSA" and implemented the Port Graham/Nanwalek Area AMSA Plan which became effective in March of 1992 (Kenai Peninsula Borough 1992). In addition, the following areas in, or adjacent to, the Lease Sale area within the Kenai Peninsula Borough have been identified as potential candidates for future AMSA planning: Anchor River Mouth, Bridge Creek Watershed, Cape Starichkof, Ninilchik/Deep Creek Waterfront, and the Seldovia Watershed (Kenai Peninsula Borough CMP 5.0).

The Kodiak Island Borough CMP recommends the following areas, which are adjacent to the Lease Sale area, as candidates for future AMSAs: Shuyak Island, Raspberry Island, and the Karluk Lake and River (Figure 8-2).

As the draft CMP for the Lake and Peninsula Borough has not been completed at this time, there are no areas adjacent to the Lease Sale applicable at this time.

8.5 STATE GAME REFUGE AND SANCTUARIES

The McNeil River State Game Sanctuary located adjacent to Kamishak Bay was established in 1967 and expanded upon in 1993 to provide permanent protection for brown bear as well as other fish and wildlife populations and habitats.

The McNeil River State Game Refuge was established in 1993 for the same objectives as the McNeil River Game Sanctuary. The refuge substantially increases the habitat for brown bear.

The Trading Bay State Game Refuge was established in 1976 to protect the following: fish and wildlife habitat, waterfowl nesting, feeding and migration, moose calving areas, spring and fall bear feeding areas, and salmon spawning and rearing habitats. The refuge includes state lands, tidelands, and submerged lands.

Other refuges include the Alaska Peninsula National Wildlife Refuge (NWR) and the Becharof NWR which are located along the central region of the Alaska Peninsula. The Kodiak Island NWR is located along the northern and southern regions of Kodiak Island.

8.6 SUMMARY

Discharges associated with oil and gas exploration in the Lease Sale areas are expected to be consistent with relevant ACMP policies. The consistency assessment is based on ACMP policies and the Kenai Peninsula Borough, Kodiak Island Borough, and Bristol Bay Borough District policies approved by local, state, and federal governments. Discharges are expected to be consistent with the objectives of subsistence uses of the coastal zone, management of all coastal habitats, and management of specific habitat types (offshore areas, estuaries, wetlands and tideflats, rocky islands and seacliffs, barrier islands and lagoons, and high energy coasts). The consistency certification made by U.S. EPA has been submitted to the State of Alaska for formal state review pursuant to 15 CFR 930.60 to 15 CFR 930.64.

9.0 MARINE WATER QUALITY CRITERIA

The determination of "unreasonable degradation" of the marine environment is to be based on consideration of the ten criteria listed in section 1.0. This chapter provides information pertinent for the consideration of the *ocean discharge* criterion listed below:

- **Criteria #10:** "Marine water quality criteria developed pursuant to Section 304(a)(1).

The 403(c) regulations of the Clean Water Act allow a 100-m (330-ft) radius mixing zone for initial dilution of drilling effluent. At the edge of the mixing zone, marine water quality criteria should be met. Compliance with water quality criteria at the edge of the mixing zone in the Cook Inlet/Shelikof Strait Planning Area is assessed in this section.

Marine water quality criteria for the protection of aquatic life (45 FR 79318, 50 FR 30784, 51 FR 43665, and 52 FR 6213) are stated as acute (a 1-h average concentration not to be exceeded more than once every three years on average) and chronic (a 96-h average concentration not to be exceeded more than once every three years on average) criteria for the protection of aquatic life, and risk-based marine water concentration criteria for the protection of humans to consumption of marine fish (CMF) (assuming a 10^{-6} cancer risk level, an average lifetime consumption of 6.5 g/day of contaminated fish and/or shellfish for a 70 kg male over a 70 yr period) (U.S. EPA 1986b). The chronic and CMF criteria are applicable to relatively continuous discharges that expose organisms in their vicinity to a relatively constant flux of pollutants. Acute criteria values are applicable to instantaneous releases or short-term discharges of pollutants. Since drilling mud discharges are episodic with durations of only a few hours, the acute water quality criteria are considered to be applicable to these discharges (Jones & Stokes 1990, p. 44).

9.1 TRACE METALS

Federal water quality criteria for metals in marine waters were stated in terms of acid-soluble concentrations of trace metals, which until recently was believed by EPA to be the "scientifically correct" basis upon which to establish water quality criteria for trace metals (U.S. EPA 1986b). Recently, however, EPA has re-evaluated the use of metals criteria in water quality standards extended to protect aquatic life (U.S. EPA 1992). This guidance supersedes past criteria document statements expressing criteria in terms of an acid-soluble analytical method.

The new EPA guidance (Interim Guidance on Interpretation and Implementation of Aquatic Life Criteria for Metals) on metals recommends that compliance be evaluated using measurements of either total recoverable metals or dissolved metals because these extraction procedures more accurately reflect the bioavailable fraction, and hence the potential toxicity of a metal (U.S. EPA 1992, p. 4). The four methods of sample preparation for metals analysis that have been recognized by EPA include 1) total metals, 2) total recoverable metals, 3) acid-soluble metals, and 4) dissolved metals. The first three of these methods measure metals that are dissolved in water, along with metals that become dissolved when samples are refluxed in acid. The severity of the extraction procedures decreases in the order: total metals > total recoverable metals > acid soluble metals method. Dissolved metals are operationally defined as those that pass through a 0.45 μm pore-size filter at the time of collection.

Evaluation of water quality compliance for the discharge of drilling muds during exploratory oil and gas drilling in previous ODCEs has relied on measurements of metals concentrations performed on generic drilling muds. Metal concentrations have been reported as "whole mud concentrations," which, are assumed to be equivalent to values obtained using the total metals method. Determination of compliance with EPA's new aquatic life criteria for metals requires that these data be used to estimate either total recoverable metals or dissolved metal concentrations. While evaluation of compliance using total recoverable metals is preferred because this method provides greater safety than does the dissolved method (U.S. EPA 1992, p. 4), no conversion factors are available for converting from the values obtained using the total metals method to total recoverable metals. However, partition coefficients for estimating dissolved metal concentrations from measurements of total metals are available. Therefore, compliance with water quality criteria will be evaluated in this ODCE using dissolved metal concentrations.

Previous ODCE's have also assessed compliance with water quality criteria using estimates of dissolved metal concentrations. This approach has been justified because exploratory drilling discharges are intermittent, diluted rapidly, and quickly deposited on the ocean floor in the vicinity of the discharge.

Toxicity from dissolved metals are thought to be of primary concern, as organisms are exposed to dissolved metals via uptake of water through gills, skin, or cell walls. Since there are little data pertaining to the partitioning of metals between dissolved and particulate phases of drilling muds and cuttings, previous ODCEs have assumed that partitioning of metals between dissolved and solid phases in drilling muds are similar to that measured for dredged material. This is believed to be a reasonable assumption because of the physical similarity of the two materials. Dredged materials are naturally occurring sediments frequently containing elevated concentrations of contaminants, with variable proportions of sand, silt, and clay particles, and containing up to 80 percent water (U.S. EPA 1988a, p. 2-9).

The concentrations of metals found in solid and dissolved fractions of samples of dredged material dumped at sea in 1978 and 1979 (Bigham et al. 1982, pp. 292-294) are shown in Table 9-1. Dissolved metal concentrations were determined by elutriate tests, which consisted of mixing one volume of sediment with four volumes of seawater, thoroughly mixing the resulting mixture, and then analyzing the filtered (0.45 μm pore-size filter) liquid fraction after allowing particulate matter to settle. The data in Table 9-1 is based upon approximately 50 separate analyses of sediments from the East and Gulf coasts. Partitioning between solid and dissolved phases varies for different metals, with cadmium having the highest solid:dissolved ratio of 0.0013.

The ratios of dissolved to solid metal concentrations used for Gulf of Mexico drilling mud-seawater mixtures is also shown in Table 9-1 (Duke and Parrish 1984). The dissolved:solid phase ratios for drilling muds and dredged materials agree reasonably well for cadmium and zinc; however, the dissolved fraction of chromium, copper, and lead in drilling muds is higher (by up to two orders of magnitude for chromium) than the fraction reported for dredged material. Previous ODCE's have used a ratio of 0.001 as a conservative estimate of the partitioning between dissolved and solid phases for all metals when evaluating compliance with water quality criteria (e.g., U.S. EPA 1984a; 1986a; 1988a; 1988b). However, given the variability of the dissolved:solid ratios between different metals, and between drilling muds and dredged materials, it is difficult to justify the use of a single value to estimate dissolved metal concentrations. Some of the partition coefficients reported in Table 9-1 for Gulf coast drilling muds are much higher than 0.001 (e.g., chromium = 0.0178), suggesting that previous evaluations of compliance with water quality criteria did not use the most conservative (i.e., protective) partition coefficient available.

TABLE 9-1. SOLUBLE AND SOLIDS METALS CONCENTRATION IN DREDGED MATERIALS DUMPED AT SEA (1978 AND 1979) AND IN DRILLING MUDS FROM GULF OF MEXICO

Metal	Dredged Materials Dumped at Sea[a]			Drilling Muds[b]		
	Mean Solid Phase (mg/kg)	Mean Liquid Phase (mg/L)	Dissolved Conc./Solid Conc.[c]	Mean Solid Phase (mg/kg)	Mean Liquid Phase (mg/L)	Dissolved Conc./Solid Conc.[c]
Arsenic	4.0	0.0049	0.0012	NR[d]	NR	NR
Barium	NR	NR	NR	279,410	1.67	5.77×10^{-6}
Cadmium	1.2	0.0016	0.0013	3.81	0.005	0.0013
Chromium	33.0	0.0048	0.0001	541	9.63	0.0178
Copper	30.4	0.0027	0.0001	54.5	0.220	0.0040
Lead	29.6	0.0068	0.0002	148	0.207	0.0014
Mercury	0.3	0.0003	0.0010	NR	NR	NR
Nickel	15.0	0.0068	0.0005	NR	NR	NR
Zinc	68.8	0.0325	0.0005	674	0.204	0.0003

[a] Reference: Bigham et al. (1982, pp. 292-294).

[b] Reference: Duke and Parrish (1984, Table 4).

[c] Liquid phase: Solid phase (kg/L).

[d] NR = Not reported.

Table 9-2 shows the maximum predicted dissolved metal concentrations for arsenic, barium, cadmium, chromium, copper, lead, mercury, and zinc at the edge of the mixing zone due to the discharge of Alaskan drilling muds in water depths of 40 m (131 ft), 70 m (230 ft), and 120 m (394 ft) in open water at three different current speeds. The drilling mud data was compiled in a database by U.S. EPA, Region X. The predicted dissolved metal concentration is based on the maximum reported drilling mud total metal concentration, the most conservative (i.e., highest) dissolved:solid phase metal ratio from Table 9-1, and the dilution factors predicted by the modified OOC model for each discharge scenario (e.g., open-water discharge in 40-m (131 ft) water depth) available in Table 3-2. In general, the calculation was performed as follows:

$$[\,Dissolved \quad Metal\,]_{MZ} = \frac{[\,Total \quad Metal\,]_{EOP}\,[\,Ratio\,]}{[\,Dilution \quad Factor\,]} \tag{1}$$

where:

$[\text{Dissolved Metal}]_{MZ}$	=	the dissolved metal concentration at the edge of the mixing zone in mg/L.
$[\text{Total Metal}]_{EOP}$	=	the drilling mud total metal concentration at the end of the pipe in mg/kg dry weight.
[Ratio]	=	the most conservative dissolved metal to total metal ratio (in kg/L) available from Table 9-1.
[Dilution Factor]	=	the modified OOC model-predicted dilution factor at the edge of the mixing zone for each of the modeling cases available in Table 3-2 (unitless).

If the lowest dissolved: solid phase ratio in Table 9-1 was less than 0.001 or no estimate was available, a value of 0.001 was used.

TABLE 9-2. COMPARISON OF MIXING ZONE BOUNDARY - PREDICTED DISSOLVED METAL CONCENTRATIONS TO ACUTE MARINE WATER QUALITY CRITERIA FOR DISCHARGE OF DRILLING MUDS IN ALASKAN WATERS

Metal	Maximum Measured Total Mud Metal Concentration[a] (mg/kg)	Dissolved: Solid Phase Metal Ratio[b]	Estimated Dissolved Metal Concentration[c] (mg/L)	Acute Marine Water Quality Criterion[d] (mg/L)	Open-Water Discharge, Current Speed of 10 cm/sec			Open-Water Discharge, Current Speed of 32 cm/sec
					Water Depth			
					40 m	70 m	120 m	120 m
					Predicted Concentration at the Mixing Zone Boundary[e] (mg/L)			
Arsenic (III)	7.9	0.001	0.0079	0.069	0.0000[f]	0.0000[f]	0.0000[f]	0.0000[f]
Barium	495,000	0.001	495	NA	0.3852	0.1832	0.1978	0.0542
Cadmium	12	0.0013	0.0156	0.043	0.0000[f]	0.0000[f]	0.0000[f]	0.0000[f]
Chromium (VI)	1,820	0.0178	32.396	1.1	0.0252	0.0120	0.0129	0.0035
Copper	86.5	0.004	0.346	0.0029	0.0003	0.0001	0.0001	0.0000[f]
Lead	1,270	0.0014	1.778	0.22	0.0014	0.0006	0.0007	0.0002
Mercury	1.46	0.001	0.00146	0.0021	0.0000[f]	0.0000[f]	0.0000[f]	0.0000[f]
Zinc	3,420	0.001	3.42	0.095	0.0027	0.0013	0.0014	0.0004
					Ratio of Predicted Metal Concentration to Acute Water Quality Criterion (HQ)			
				Arsenic (III)	0.0000[f]	0.0000[f]	0.0000[f]	0.0000[f]
				Barium	–[g]	–[g]	–[g]	–[g]
				Cadmium	0.0003	0.0001	0.0001	0.0000[f]
				Chromium (VI)	0.0229	0.0109	0.0117	0.0032
				Copper	0.1034	0.0345	0.0345	0.0131
				Lead	0.0064	0.0027	0.0032	0.0009
				Mercury	0.0005	0.0002	0.0003	0.0000[f]
				Zinc	0.0284	0.0137	0.0147	0.0042

Note: Data not available for an open-water discharge current speed of 20 cm/sec.

a Maximum measured total mud metal concentrations from Table 2-2 in Section 2.0.

b The most conservative dissolved:solid phase metal ratio from Table 9-1 (Gulf of Mexico drilling muds or dredged material). If the ratio was less than 0.001 or no value was available, the value of 0.001 was used.

c The product of the maximum measured total mud metal concentration and the dissolved:solid phase metal ratio.

d U.S. EPA Water Quality Criteria (1991).

e The predicted dissolved-metal concentrations calculated by dividing the estimated dissolved-metal concentration by the appropriate modified OOC model-predicted dilution factor in Table 3-2 of Section 3.0.

f Values of 0.0000 indicate that the predicted concentration is less than 0.000099 mg/L.

g There is no acute marine water quality criterion for barium available for comparison.

The predicted dissolved metal concentration may be compared directly to the marine acute water quality criterion presented in Table 9-2. However, the ratio of the marine acute metal criterion to the predicted dissolved metal concentration is also presented in these tables to facilitate comparison with the metals water quality criteria. The ratio was calculated as follows:

$$[\,Hazard\ \ Quotient\,] = \frac{[\,Dissolved\ \ Metal\,]_{MZ}}{[\,Metal\ \ Criterion\,]} \qquad (2)$$

where:

[Hazard Quotient] = the level of concern relative to the selected reference toxicity value (i.e., the marine acute water quality metal criterion).

[Metal Criterion] = the marine acute water quality criterion in mg/L.

The hazard quotient (HQ) values shown in Table 9-2 should be interpreted in the following way:

- Compliance with acute water quality criteria: HQ $<<<$ 1.0. HQ values substantially lower than 1.0 are indicative of unlikely, or minimal effects.

- Potential exceedance of acute water quality criteria: HQ $\leq$ 1.0. HQ values approximating 1.0 are usually considered to indicate the need for further analysis in order to better define the potential for risk (U.S. EPA 1992).

For all metals, dissolved concentrations are estimated to be well below (HQ $<$ 0.5) acute water quality criteria (see Table 9-2).

The inverse of the HQ can be thought of as the factor by which the predicted concentration would have to be multiplied to exceed water quality criteria. For the most conservative modeling case mentioned above (40 m water depth, 10 cm/sec current speed), these factors are as follows: copper, 10; zinc, 35; chromium, 44; lead, 156; mercury, 2,000; cadmium, 3,333; and arsenic, >10,000.

9.2 ORGANIC COMPOUNDS

Organic compounds found in drilling muds also have the potential to cause marine water quality criteria exceedances. Tables 2-5 and 2-6 summarize results from several studies that examined organic chemical concentrations in drilling muds and mineral oils, respectively. None of the individual compounds that were detected have established acute marine water quality criteria, and only one, naphthalene, has a reported lowest observed effects level (LOEL). Naphthalene concentrations are not expected to exceed the LOEL unless dilutions are less than 2.1. All of the dilutions predicted for model cases in this ODCE exceed this value. More organic chemical data are needed to fully assess the potential for organic compounds in discharged drilling muds to violate water quality criteria.

9.3 SUMMARY

Trace metals in drilling mud discharges from exploratory oil and gas wells are not expected to exceed acute marine water quality criteria discharged to waters (40 m or greater). An assessment of the potential for organic compounds to exceed water quality criteria was not possible, with the exception of naphthalene, due to a lack of data concerning the concentrations of such materials in drilling muds, and the lack of applicable water quality criteria for some of the chemicals detected in the muds. The only organic compound which could be evaluated, naphthalene, was shown to have little potential to exceed acute water quality criteria.

10.0 DETERMINATION OF UNREASONABLE DEGRADATION

Chapter 1 of this ODCE provides the regulatory definition of unreasonable degradation of the marine environment (40 CFR 125.121[e]) and indicates the ten criteria which are to be considered when making this determination (40 CFR 125.122). The actual determination of whether the discharge will cause unreasonable degradation is made by the U.S. EPA Regional Administrator. The intent of this chapter is to briefly summarize information pertinent to the determination of unreasonable degradation with respect to the ten criteria.

10.1 CRITERIA 1

The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged.

- It is estimated that the average exploratory well will produce 327 metric tons (360 tons) of dry drilling muds and 399 metric tons (440 tons) of dry rock cuttings.

- Drilling muds are complex mixtures of clays, barite, and specialty additives. The composition of drilling mud can vary over a wide range from one hole to the next, as well as during the course of drilling a single hole.

- Existing data are inadequate for the quantification of potential long-term effects to aquatic life from consumption of aquatic organisms that have been exposed to discharges from exploratory oil drilling operations. Available data, however, suggest that the hazard is toxicologically insignificant.

10.2 CRITERIA 2

The potential transport of such pollutants by biological, physical, or chemical processes.

- Drilling muds tend to be diluted rapidly following discharge. During open water discharge, dilution of dissolved components are on the order of 2,500:1 and 9,100:1 in deep waters [120 m (394 ft)] for current speeds of 10 cm/sec and 32 cm/sec respectively, and 1,300:1 to 2,700 in waters [40 m to 70 m (131 to 230 ft), respectively].

- Deposition and accumulation of exploratory drilling solids is limited to the immediate discharge area.

- Inflowing waters from the Gulf of Alaska have mean current speeds of 10-15 cm/sec during the summer months which increase to 25-30 cm/sec during the winter months. The mean current speeds in Shelikof Strait are estimated to be approximately 13-26 cm/sec in the main channel.

10.3 CRITERIA 3

The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain.

- Benthic communities outside the 100 m mixing zone may be adversely impacted by smothering due to sediment accumulations greater than 1 cm when discharge occurs in open water at depths of 40 m.

- A worst case analysis for the Industry Alternative Scenario (6 exploratory wells and 2 delineation wells) indicates that approximately 0.0008 percent of the Lease Sale area would receive deposition of drilling mud in amounts thought to have an adverse impact on benthic communities [i.e. 1 cm (0.4 in)].

- Research on the chemical toxicity of drilling muds has indicated that larval stages and planktonic organisms are the most sensitive of the Alaskan species that have been evaluated. Estimated drilling mud concentrations at the edge of the mixing zone are above 96-h LC50 levels for some of these species. However, since drilling mud discharges are episodic with durations of only a few hours, it is unlikely that organisms would be exposed for periods of time typically used to determine acute toxicity. There are insufficient data on the adverse impacts to Alaskan species following chronic exposure to drilling muds.

- The Steller sea lion, which occurs throughout the Lease Sale area, is listed as a threatened species pursuant to the Endangered Species Act. There are no resident cetacean species in the planning area listed as threatened or endangered. The beluga whale is listed as a candidate species. The endangered gray, humpback, fin, and sei whales may occur seasonally in the planning area. The Arctic and American peregrine falcons, listed as threatened and endangered respectively, may occur seasonally in the planning area. The Steller's eider is listed as a candidate species and occurs in the vicinity of the planning area. Impacts to these species may potentially occur from behavioral changes resulting from drillship noise, drilling support activities, and impacts to potential prey.

10.4 CRITERIA 4

The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism.

- Shelikof Strait is a known migratory route for gray whales and a possible migratory route for fin and humpback whales. This area is also a major spawning area for walleye pollock.

- Cook Inlet and Kachemak Bay are important areas for killer whales, beluga whales, Dall's porpoises, and harbor porpoises. Sea otters utilize the Kenai Peninsula, Kodiak Island, and Cook Inlet areas. Steller sea lions utilize the entire Lease Sale area, with Shelikof Strait being a particularly important habitat resource area.

- Areas of major significance to waterfowl include lower and upper Cook Inlet, Kodiak Island, and the eastern side of the Alaska Peninsula. Kachemak Bay, Shelikof Strait, and the Barren Islands are important resource areas for many seabirds.

- Kamishak Bay, Kachemak Bay, and part of Shelikof Strait are nurseries for Tanner crab as well as important habitats for King and Dungeness crabs.

10.5 CRITERIA 5

The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs.

- No marine sanctuaries, as defined by 40 CFR 125.122(5), are known to be located in the Lease Sale area. However, designated islands surrounding Kodiak and Afognak Islands, the Barren Islands, designated islands and inlets on the south side of the Alaska Peninsula, Augustine Island, and the Semidi Islands are located adjacent to the sale area, and comprise part of the Alaska Maritime National Wildlife Refuge.

- There are six designated Critical Habitat Areas in the vicinity of the Lease Sale area: Kachemak Bay CHA, Clam Gulch CHA, Kalgin Island CHA, Fox River Flats CHA, Redoubt Bay CHA, and Tugidak CHA.

- The National Marine Fisheries Service has proposed to designate critical habitat for the Steller sea lion pursuant to the Endangered Species Act. Specific proposal sites directly relating to the Lease Sale area are: 1) all Steller sea lion rookeries and major haulouts (>200 Steller sea lions) located within state and Federally managed waters off Alaska, including a zone that extends 3,000 feet seaward from rookeries and major haulouts in Alaska located east of 144° W longitude, or 20 nm seaward from rookeries and major haulout sites west of 144° W longitude and, 2) one proposed aquatic zone for critical aquatic foraging habitat that is located exclusively in the Gulf of Alaska (Shelikof Strait).

- The Port Graham/Nanwalek area located on the tip of the Kenai Peninsula has been identified as an Area which Merits Special Attention.

- There are two state game refuges located adjacent to the Lease Sale area: the McNeil River State Game Refuge and the Trading Bay State Game Refuge. Also located adjacent to the sale area are the following; the McNeil River State Game Sanctuary, the Alaska Peninsula National Wildlife Refuge, the Becharof National Wildlife Refuge, and the Kodiak Island National Wildlife Refuge.

10.6 CRITERIA 6

The potential impacts on human health through direct and indirect pathways.

- Exploratory oil and gas drilling activities and discharges are not expected to result in significant impacts to human health. The rationale for this assessment is based upon the following observations: 1) bioconcentration factors for metals present in drilling muds other than methylmercury are too low to result in substantial biomagnification, 2) mercury is a relatively minor constituent of drilling muds, 3) the areas affected by exploratory drilling discharges are too small to contribute substantially to the diet of fish or shellfish harvested by commercial, recreational, or subsistence fisheries.

10.7 CRITERIA 7

Existing or potential recreational and commercial fishing, including finfishing and shellfishing.

- Nearshore locations used for recreational and commercial fisheries are predominately outside areas that could conceivably be impacted by activities conducted during exploratory drilling.

- Exploratory operations within the Lease Sale area may adversely impact commercial fisheries. Commercial fisheries in the Lease Sale area include: salmon, groundfish, herring, halibut, Tanner and Dungeness crabs, and shrimp. The likelihood of impacts to commercially harvested species is strongly dependent on the timing and location of exploratory drilling discharges, although the overall impact to quantity and quality is expected to be minimal.

10.8 CRITERIA 8

Any applicable requirements of an approved Coastal Zone Management Plan.

- Discharges associated with oil and gas exploration in the Lease Sale area are expected to be consistent with relevant Alaska Coastal Management Program policies, the Kenai Peninsula Borough Coastal Management Program, the Kodiak Island Borough Coastal Management Program, and the Lake and Peninsula Borough Coastal Management Program.

- Nearshore locations used for subsistence fisheries are predominately outside areas that may be impacted by activities conducted during exploratory drilling. Therefore, discharges associated with oil and gas exploration in the Lease Sale area are expected to be consistent with relevant Borough policies.

10.9 CRITERIA 9

Such other factors relating to the effects of the discharge as may be appropriate.

- No other factors have been identified relating to the effects of the discharge.

10.10 CRITERIA 10

Marine water quality developed pursuant to Section 304(a)(I)

- The discharge of drilling muds into open-water at depths of 40 m and greater is expected to comply with acute water quality for all metals.

- An assessment of the potential for organic compounds to exceed water quality criteria was not possible, with the exception of naphthalene, due to a lack of data concerning the concentrations of such compounds in drilling muds, and the lack of applicable water quality criteria. Naphthalene was shown to have little potential to exceed acute water quality criteria.

While the information contained in this ODCE is intended to provide the basis for the determination of unreasonable degradation, it should be cautioned that significant gaps exist in our understanding of the risk of discharging drilling muds to the marine environment, both generally and in the Lease Sale area. Of particular concern are the long-term chronic and sublethal impacts of drilling muds and cuttings on marine biota. In addition, uncertainty exists regarding determinations of compliance with federal water quality criteria. To assist in filling these data gaps it is recommended that research be conducted to accomplish the following:

- Develop more laboratory data on sublethal and chronic effects at environmentally realistic concentrations.

- Generate data on the bioaccumulation of specific organisms and the interpretation of the significance of bioaccumulation.

- Conduct field studies to quantify the environmental concentrations of drilling fluids (e.g., Duke and Parrish 1990).

- Determine total recoverable metal concentrations of drilling muds and partition coefficients for calculating dissolved metal concentrations under ambient conditions to allow an acceptable evaluation of toxicological risk to marine biota that can be used to evaluate compliance with water quality standards.

- Conduct laboratory/field studies to determine the critical amount and rate of sedimentation that will adversely impact benthic communities in Alaskan waters.

- Identify locations that include critical substrate used by commercially important epibenthic invertebrates.

11.0 MONITORING RECOMMENDATIONS

Given that there is uncertainty regarding the ecological impacts of exploratory drilling discharge, it is recommended that monitoring should be undertaken to verify that the discharge of drilling muds and cuttings and other permitted discharges will not produce conditions that in the future would lead to unreasonable degradation. The specifics of each monitoring program will be determined by the Director in consultation with the Regional Environmental Supervisor of the Alaska Department of Environmental Conservation and the permittee (53 FR 2638). The need for monitoring of additional exploratory drilling operations will have to be decided on a case-by-case basis, dependent on the results of the initial monitoring program (53 FR 2638). Recommendations for additional monitoring of currently permitted discharges and biological monitoring of different taxa are provided below.

11.1 ADDITIONAL DISCHARGE MONITORING

The current general permit for the Cook Inlet/Shelikof Strait Planning Area (NPDES permit AKG285000) specifies a number of chemical analyses that must be performed prior to the discharge of drilling muds. Other permitted discharges, however, do not have similar requirements for chemical analyses. Chemical inventories similar to those required for drilling muds are required for certain other permitted discharges (e.g., cooling water and desalinization units), but the concentrations of the added chemicals in the actual discharge remains largely unknown. Periodic monitoring of discharges to which components known to be toxic to marine life (e.g., biocides) have been added is recommended. If concentrations of toxic pollutants reach levels of concern, effluent toxicity tests can be performed to determine if the discharge meets permit requirements.

11.2 BENTHIC INVERTEBRATES

Monitoring of benthic invertebrate populations is conditionally recommended to determine whether the benthic community is adversely affected by thin layers of drilling muds and cuttings, which are likely to be deposited when drilling in deeper waters. As discussed in the Sale 109 ODCE (U.S. EPA 1988, p. 9-3), the benthic monitoring program should measure sedimentation depths, the size of the sedimented particles, and concentrations of selected aromatic hydrocarbons and metals in the interstitial water of the top 4 cm (1.6 in) of sediment. Densities of key species and benthic community characteristics should also be monitored.

Toxicity tests of drilling muds and cuttings containing mineral oil should be conducted with organisms that inhabit the Lease Sale area. Also, toxicity tests should be conducted on sediments collected from within and outside of the prescribed mixing zone for the well. Sediment toxicity results from near the well site would be compared with results from reference sediments collected in a region not impacted by oil and gas drilling operations.

An attempt should be made to determine the chronic effects to species of interest in the Lease Sale area. Of particular concern are the impacts arising from chronic leaching of metals, hydrocarbons, and the most persistent biocides in drilling mud deposited on the bottom. In addition, insufficient evidence exists to demonstrate that data from short-term acute toxicity tests reveal subtle adverse effects at the ecosystem level of biological complexity.

11.3 FISH

Fish populations within the sale area are widespread and not small enough to be considered threatened or endangered. However, spawning grounds for several species, particularly walleye pollock, are located within the Lease Sale area. The locations of these spawning grounds have been identified. A monitoring program similar to that described above for benthic invertebrates is warranted for the spawning habitat of walleye pollock.

11.4 MARINE MAMMALS

Monitoring of marine mammal populations should be carried out if 1) the site selected for drilling lies within a significant feeding area of cetaceans, pinnipeds, and sea otters, or a significant calving/pupping area for cetaceans and pinnipeds, 2) monitoring of the benthic invertebrate prey community reveals that reductions may adversely impact marine mammals that rely on these organisms, and 3) monitoring of fish communities reveal that reductions in abundance may adversely impact the marine mammals that depend upon these species.

Steller sea lions prey primarily on walleye pollock which spawn in Shelikof Strait and lower Cook Inlet. A monitoring program for this species should include quantification of dietary requirements versus prey availability to determine if animals are nutritionally stressed. Populations of pollock would be monitored before and after drilling activities to quantify the effects of drilling discharges.

Baleen whales such as the gray, humpback, and fin whales may use the Cook Inlet/Shelikof Strait Planning Area as summer feeding grounds. These animals rely on dense aggregations of euphausiids and amphipods (U.S. DOI 1992). Areas of food concentration could be of critical importance to these whales. The monitoring program recommended would quantify infaunal and epifaunal amphipod concentrations in potential deposition areas around drilling sites, as well as other zooplankton species in the vicinity of drilling sites. Populations would be monitored before and after drilling activities to quantify the effects of drilling discharges.

A monitoring program for the beluga whale stock in Cook Inlet is recommended to determine; 1) the behavioral sensitivity to effects due to drilling discharges, noise, or other factors associated with offshore oil and gas exploration, 2) a statistically valid estimate of the total stock, 3) seasonal distribution, 4) patterns of habitat use, and 5) quantitative data for key prey organisms.

11.5 MARINE BIRDS AND WATERFOWL

Monitoring of marine bird and waterfowl populations should be carried out if the site selected for drilling lies within a significant foraging area of birds, or if monitoring studies suggest that drilling activities will result in a substantial reduction in benthic and pelagic species preyed upon by marine birds. As discussed in section 4.4, the Cook Inlet and Shelikof Strait regions are important foraging areas for marine birds and waterfowl as well as containing numerous nesting and breeding sites. Therefore, monitoring efforts should pay particular attention to this area.

11.6 ADDITIONAL CONSIDERATIONS

It is recommended that the OOC model, or other available models, be considered for use to evaluate impacts of drilling mud discharges to shallow waters [5 m (16 ft) to 39 m (128 ft)]. Although shallow waters encompass only a small portion of the lease sale area, these regions may represent critical areas for biological communities.

12.0 REFERENCES

Atema, J.D., F. Leavitt, D.E. Barshaw, and M.C. Cuomo. 1982. Effects of drilling muds on behavior of the American lobster, *Homarus americanus*, in water column and substrate exposures. Can. J. of Fish. Aqua. Sci. 39:675-689.

Baird, P.A. 1983. Glaucous-winged Gull (*Larus glaucescens*). Baird, P.A. and P.J. Gould (eds.) 1983. The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. DOC, NOAA, OCSEAP Final Report 45(1986): 237-376.

Baird, P.A., and P.J. Gould (eds) 1983. The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. DOC, NOAA, OCSEAP Final Report 45 (1986): 121-504.

Batelle. 1984. Final report for research on organic chemical characterization of diesel and mineral oils used as drilling mud additives. Prepared for Offshore Operators Committee, Environmental Subcommittee. Battelle New England Marine Research Laboratory.

Bigham, G., T. Ginn, A.M. Soldate, and L. McCrone. 1982. Evaluation of ocean disposal of manganese nodule processing waste and environmental considerations. Contract TC-3514. Prepared for NOAA, Office of Ocean Minerals and Energy, Washington, D.C. Tetra Tech Inc., Bellevue, WA. 423 pp.

Blackburn, J.E. 1979. Pelagic and Demersel Fish Assessment in the lower Cook Inlet estuary system. pp. 107-382 Environmental assessment of the Alaskan continental shelf, Vol. 17. Biological Studies. NOAA/MMS, Boulder, CO.

Boehm, P., L. LeBlanc, J. Trefry, P. Marajh-Whittemore, J. Brown, A. Schutzberg, and A. Kick. 1990. Monitoring hydrocarbons and trace metals in Beaufort Sea sediments and organisms. Final report to: U.S. Department of the Interior Minerals Management Service, Anchorage, AK. OCS Study MMS 90-0054. Arthur D. Little, Inc. Cambridge, MA.

Bouchet, G. C. 1983. Estimation of the abundance of Dall's porpoise (*Phocoenoides dalli*) in the North Pacific Ocean and Bering Sea by strip transect methodology, 1978-1983. International Whaling Commission. SC/35/SM/Z, June 1983. 19 pp.

Brady, J. 27 July 1993. Personal Communication (Telephone with Ms. Kimberle Stark, Tetra Tech, Inc., Redmond, WA). Alaska Dept. of Fish and Game. Anchorage, AK.

Brandsma, M.G., L.R. Davis, R.C. Ayers Jr., and T.C. Sauer Jr. 1980. a computer model to predict the short term fate of drilling discharges in the marine environment. pp. 351-381. Proc. of the Symposium: Research on Environmental Fate and Effects of Drilling Fluids and Cuttings, Lake Buena Vista, FL.

Brandsma Engineering. 1991. Simulation of discharge scenarios on the Alaska outer continental shelf. Draft report. Brandsma Engineering, Durango, CO. 43 pp.

Brandsma Engineering. 1992. Supplemental simulations of seabed deposition for Beaufort and Chukchi general permit. Draft report. Brandsma Engineering, Durango, CO. 17 pp.

Bristol Bay Coastal Resource Service Area Board. 1982. Bristol Bay Coastal Resource Service Area Coastal Management Plan. Billingham, AK.

Brown, D.A., S.M. Bay, and R.W. Gossett. 1985. Using the natural detoxification capacities of marine organisms to assess assimilative capacity. pp. 364-382. Aquatic Toxicology and Hazard Assessment: Seventh Symposium. ASTM STP 854. R.D. Cardwell, R. Purdy, and R.C. Bahnr (eds.). American Society for Testing and Materials, Philadelphia, PA.

Byar, A. 28 May 1993 Personal Communication (Statistics acquired by Mr. Tad Deshler, Tetra Tech, Redmond, WA). U.S. EPA, Region X, Ocean Programs Section. Seattle, WA.

Calkins, D.G. 1987. Marine mammals. pp. 527-558 D.W. Hood and S.T. Zimmerman, eds., The Gulf of Alaska: Physical environment and biological resources. (Order number PB87-103230). U.S. Department of Commerce, Springfield, VA. 655 pp.

Calkins, D.G. 1992. Steller sea lions: still threatened in Alaska. Alaska's Wildlife. pp 22-26.

Calkins, D.G., and K.B. Schneider. 1985. Species account: The sea otter (*Enhydra lutris*). Alaska Department of Fish and Game.

Calkins, D., and E. Goodwin. 1988. Investigation of the declining sea lion population in the Gulf of Alaska. August 15. Alaska Department of Fish and Game. Anchorage, AK.

Calkins, D.G., K.W. Pitcher, and K.B. Schneider. 1975. Distribution and abundance of marine mammals in the Gulf of Alaska. Alaska Department of Fish and Game.

Callahan, M., M. Slimak, N. Gabel, I. May, C. Fowler, J.R. Freed, P. Jennings, R. Durfee, F. Whitmore, B. Maestri, W. Mobey, B. Holt, and C. Gould. 1979. Water-related fate of 129 priority pollutants. Vol. 1. EPA 440/4-4-79-029a. U.S. Environmental Protection Agency, Office of Water Planning and Standards, Washington, D.C. 450 pp.

Carls, M.G. and S.D. Rice. 1984. Toxic contributions of specific drilling mud components to larval shrimp and crabs. Mar. Environ. Res. 12:45-62.

CENTEC. 1984. Results of laboratory analysis and findings performed on drilling fluids and cuttings. Prepared for U.S. Environmental Protection Agency, Effluent and Guidelines Division, Energy and Mining. CENTEC Analytical Services, Washington, D.C. 51 pp. + appendices.

Cooney, R.T. 1987. Common zooplankton and micronekton for oceanic and shelf regions, Kodiak and lower Cook Inlet. pp. 285-303 D.W. Hood and S.T. Zimmerman, eds., The Gulf of Alaska: physical environmental and biological resources. U.S. DOC, Springfield, VA. 655 pp.

Crawford, T.W. 1981. Vertebrate prey of *Phocoenoides dalli* (Dall's porpoise) associated with the Japanese high seas salmon fishery in the North Pacific Ocean. M.S. Thesis, University of Washington. Seattle, WA. 72 pp.

Damkaer, D.M. 1977. Initial zooplankton investigations in Prince William Sound, Gulf of Alaska, and lower Cook Inlet. pp. 137-274 Environmental assessment of the Alaskan continental shelf. Annual; reports of principal investigations for the year ending March 1977. Vol. X: Receptors - fish, littoral benthos. NOAA/BLM, Boulder, CO.

Duke, T.W., and P.R. Parrish. 1984. Results of the drilling research program sponsored by the Gulf Breeze Environmental Research Laboratory, 1976-1984, and their application to hazard assessment. EPA 600/4-84-055. U.S. Environmental Protection Agency Environmental Research Laboratory. Gulf Breeze, FL.

Estes, J.A., and J.F. Palmisano. 1974. Sea otters: their role in structuring nearshore communities. Science 185:1058-1060.

Fall, J.A.(ed). 1991. Subsistence aarvests and uses in several Gulf of Alaska communities in the second year following the Exxon Valdez oil spill. Alaska Department of Fish and Game.

Feder, H.M. 1981. Distribution, abundance, community structure, and tophic relationships of the nearshore benthos of Cook Inlet. pp. 45-676 Environmental assessment of the Alaskan continental shelf. Final reports of principal investigators. Vol. 14: Biological studies. NOAA/BLM, Boulder, CO.

Feely, R.A., G.J. Massoth, A.J. Paulson, M.F. Lamb, and E.R. Martin. 1981. Distribution and elemental composition of suspended matter in Alaskan coastal waters. NOAA Tech. Memorandum ERL PMEL-27.

Feely, R.A., and G.J.Massoth. 1984. Sources, competition, and transport of suspended particulate matter in lower Cook Inlet and S.W. Shelikof Strait, Alaska. NOAA Tech. Rep. ERL 415-PMEL 34. Pacific Marine Environmental Lab., Seattle, WA. 28 pp.

Flint, K. 8 March 1993. Personal Communication (Meeting with Mr. Tad Deshler, Tetra Tech, Inc., Redmond, WA). U.S. EPA, Region X, Ocean Programs Section, Seattle, WA.

Freed, L. 11 August 1993. Personal Communication (Telephone with Ms. Kimberle Stark, Tetra Tech, Inc., Redmond, WA). Kodiak Island Borough. Kodiak, AK.

Gossett, R.W., D.A. Brown, and D.R. Young. 1983. Predicting the bioaccumulation of organic compounds in marine organisms using octanol/water partition coefficients. Mar. Pollut. Bull. 14:387-392.

Goyer, R.A. 1986. Toxic effects of metals.. pp. 582-635. Casarett and Doull's Toxicology: The Basic Science of Poisons. C.D. Klaassen, M.O. Amdur, and J. Doull (eds). Macmillan Publishing Co., New York.

Hale, S.S. 1972. Some reactions of the ocean quahog *Arctica islandica* upon burial. Mimeo report. University of Rhode Island, School of Oceanography, Kingston, RI.

Hatch, S.A. 1983a. Storm Petrels (*Oceanodroma spp.*). Baird, P.D. and P.J. Gould (eds). 1983. The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. DOC, NOAA, OCSEA Final Report 45(1986): 171-206.

Hatch, S.A. 1983b. Northern Fulmar (*Filmaris glacialis*). Baird, P.A. and P.J. Gould (eds.). 1983. The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. DOC, NOAA, OCSEAP Final Report 45 (1986):143-170.

Hazardous Substances Database. 1992. On-line database maintained by National Library of Medicine, Bethesda, MD.

Incze, L.S., A.W. Kendall, J.D. Schumacher, and R.K. Reed. 1989. Interactions of a mesoscale patch of larval fish (*Theragra chalcogramma*) with the Alaska Coastal Current. Cont. Shelf Research 9(3):269-284.

Jackson, J.B., and F.N. Kurz. 1982. Gulf of Alaska and lower Cook Inlet summary Report 3. Prepared for U.S. D0I, MMS in cooperation with U.S. Geological Survey. U.S.G.S. Open-file Report 82-20.

Jarvela, L.E. and L.K. Thursteinson, eds., 1989. Gulf of Alaska, Cook Inlet, and North Aleutian Basin Information Update Meeting, Feb 7-8, 1989. U.S. DOC, NOAA, OCSEAP study MMS-89-0041.

Jones & Stokes. 1989a. Fates and effects of exploratory phase oil and gas drilling discharges in the Beaufort Sea Planning Area, Lease Sale 124. Prepared for U.S. Environmental Protection Agency. Jones & Stokes Associates, Bellevue, WA.

Jones & Stokes. 1989b. Fates and effects of exploratory phase oil and gas drilling discharges in the Navarin Planning Area, Lease Sale 107. Prepared for U.S. Environmental Protection Agency. Jones & Stokes Associates, Bellevue, WA.

Jones & Stokes. 1990. Fates and effects of exploratory phase oil and gas drilling discharges in the Beaufort Sea Planning Area, Lease Sale 124. Prepared for U.S. Environmental Protection Agency. Jones & Stokes Associates, Bellevue, WA.

Jones & Stokes, Inc. 1993. Fate and effects of exploratory phase oil and gas drilling discharges in the Cook Inlet Planning Area, Lease Sale 149. Draft Appendix. Prepared for U.S. EPA. Region X, Seattle, WA.

Kenai Peninsula Borough (KPB). 1990. Kenai Peninsula Borough Coastal Management Program. Kenai Peninsula Borough Resource Planning Department, Soldotna, AK.

Kendall, A., J. Dunn, and R. Wolotira. 1980. Zooplankton including ichthyoplankton and decapod larvae of the Kodiak Shelf. Northwest Alaska Fisheries Center Report 80-8.

Kendall, A., and T. Nakatani. 1992. Comparisons of early life history characteristics of Walleye Pollock in Shelikof Strait, Gulf of Alaska and Funka Bay, Hokkaido, Japan. Fish Bulletin 90(1) 1992. pp. 129-138.

Kodiak Island Borough (KIB). 1984. Kodiak Island Borough Coastal Management Program. Kodiak, AK.

Kranz, P.M. 1974. The anastrophic burial of bivalves and its paleoecological significance. J. of Geol. 82:237-265.

Krasnow, L.D., and G.A. Sanger. 1982. Feeding ecology of marine birds in the nearshore waters of Kodiak Island. U.S. DOC, NOAA, OCSEAP Final Report 45(1986):505-630.

LaBelle, J.C., and J.L. Wise 1983. Alaska Marine Ice Atlas. Arctic Environmental Information and Date Center, University of Alaska.

Larrance, J.D., D.A. Tennant, A.J. Chester, and P.A. Ruffio. 1977. Phytoplankton and primary productivity in the northeastern Gulf of Alaska and lower Cook Inlet. pp. 1-136 Environmental assessment of the Alaskan continental shelf. Annual reports of principal investigation for the year ending March 1977. Col. X: Receptors NOAA/BLM, Boulder, CO.

Loughlin, T.R. 1989. Status of Northern Fur seals. Proceeding of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin information update meeting, Feb. 7-8, 1989. OCEAP study MMS-89-0041.

Macek, K.J., S.R. Petrocelli, and B.H. Sleight III. 1979. Considerations in assessing the potential for, and significance of, biomagnification of chemical residues in aquatic food chains. pp. 251-258. American Society for Testing and Materials Paper no. 667. L.L. Marking and R.A. Kimerle (eds.). Philadelphia, PA.

Marine Mammal Commission. 1987. Annual report of the Marine Mammal Commission, calendar year 1987. pp. 37-38.

Marine Mammal Commission. 1989. Annual report of the Marine Mammal Commission, Calendar Year 1989.

Mauer, D.L., R.T. Keck, J.C. Tinsman, W.A. Leathem, C.A. Wethe, M. Huntzinger, C. Lord, and T.M. Church. 1978. Vertical migration of benthos in simulated dredged material overburdens. Vol. I: Marine benthos. Technical Report D-78-35. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

McGurk , M.D. 1989. Relationships of growth and survival of pacific herring to environmental factors Proceedings of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin information update meeting, Feb 7-8, 1989. OCSEAP Study MMS-89-0041.

Menzie, C.A. 1982. The environmental implications of offshore oil and gas activities. Environ. Sci. Technol. 16:454-472.

Mills, M.J. 1992. Harvest, catch, and participation in Alaska sport fisheries during 1991. Alaska Department of Fish and Game.

Morris, R. 16 August 1993. Personal Communication (Telephone with Ms. Kimberle Stark, Tetra Tech, Inc., Redmond, WA). National Marine Fisheries Service. Anchorage, AK.

National Marine Fisheries Service. (NMFS) 1989. Taking of marine mammals incidental to commercial fishing operations; interim exemption for commercial fisheries. NOAA, NMFS, Federal Register Vol. 54, no. 75, pp. 16072-86.

National Marine Fisheries Service. (NMFS) 1993. Environmental assessment on proposed regulations to designate critical habitat for the Steller Sea Lion. U.S. DOC, NOAA, NMFS.

National Marine Fisheries Service. (NMFS) 1993b. Designated critical habitat; Steller sea lion. NOAA, NMFS, Federal Register 58 (165): 45269-45285.

National Research Council. 1983. Drilling fluids and cuttings in the marine environment. Marine Board, panel on fates and effects of drilling fluids and cuttings in the marine environment. National Academy Press. Washington, D.C. 180 pp.

Neff, J.M. 1982. Fate and biological effects on oil well drilling fluids in the marine environment: A literature review. EPA-600/3-82-064. U.S. Environmental Protection Agency, Environmental Research Laboratory, Gulf Breeze, FL. 150 pp.

Neff, J.M., R.J. Breteler, F.I. Saksa, and R.S. Carr. 1985. Chronic effects of drilling fluids discharged to the marine environment, with emphasis on bioaccumulation biomagnification potential of drilling fluid metals. American Petroleum Institute publication no. 4397.

Northern Technical Services (NORTEC). 1984. Reconnaissance study, drilling mud and cuttings disposal site, Seal Island, Beaufort Sea, Alaska. Final Report. Prepared for Shell Western E&P Inc. NORTEC, Anchorage, AK. 27 pp.

Northern Technical Services (NORTEC). 1985. Environmental effects of below-ice drilling effluent discharges, Mukluk Island, Well no. 1, Beaufort Sea, Alaska. Prepared for SOHIO Alaska Petroleum Company. NORTEC, Anchorage, AK. 57 pp.

Nysewander, D.R. 1983. Black-legged Kittiwake (*Rissa tridactyla*). Baird, P.A. and P.J. Gould (eds). 1983. The breeding biology and feeding ecology of marne birds in the Gulf of Alaska. U.S. DOC, NOAA, OCSEAP Final Report 45(1986): 95-348.

Nysewander, D.R. 1983b. Cormorants (*Phalacrocorax spp.*) Baird, P.A. and P.J. Gould (eds.). 1983. The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. DOC, NOAA, OCSEAP Final Report 45 (1986): 207-236.

Oliver, J.S., and P.N. Slattery. 1973. Dredging, dredge spoil disposal and benthic invertebrates in Monterey Bay. Moss Landing Marine Laboratory Report. Monterey, CA. 130 pp.

Olla, B.L., V.B. Estelle, R.C. Swartz, G. Braun, and A.L. Studholme. 1988. Responses of polychaetes to cadmium-contaminated sediment: Comparison of uptake and behavior. Environ. Toxicol. Chem. 7:587-592.

O'Reilly, J.E., T.C. Saver, R.C. Ayers, Jr., M.G. Brandsma, and R. Meek. 1989. Field verification of the OOC mud discharge model. pp. 647-667. Drilling wastes, Proc. of the 1988 International conference on drilling wastes, Calgary, Alberta, Canada. F.R. Engelhardt, J.P. Ray and A.H. Gilliam (eds). Elsevier Science Publishers Ltd., London, England.

Osborne, J. and C. Leeder. 1989. Acute and chronic toxicity of base oil and cuttings from three wells drilled in the Beaufort Sea. pp. 481-494. Drilling Wastes, Proc. of the 1988 International Conference on Drilling Wastes, Calgary, Alberta, Canada. F.R. Engelhardt, J.P. Ray, and A.H. Gilliam (eds). Elsevier Science Publishers Ltd., London, England.

Parrish, P.R., and T.W. Duke. 1990. Effects of drilling fluids on marine organisms. pp. 207-217. Oceanic Processes In Marine Pollution. Volume 6. D.J. Baumgartner and I.W. Duedall (eds.). Robert E. Krieger Publ. Co., Malabar, FL.

Payne, J.F., J. Kiceniyuk, U. Williams, L. Fancey, W. Melvin, and R. Addison. 1989. Bioaccumulation of polycyclic aromatic hydrocarbons in flounder (*Pseudopleuronectes americanus*) exposed to oil-based drill cuttings. pp. 427-438. Drilling Wastes, Proc. of the 1988 International Conference on Drilling Wastes, Calgary, Alberta, Canada. F.R. Engelhardt, J.P. Ray, and A.H. Gilliam (eds). Elsevier Science Publishers Ltd., London, England.

Perez M.A., and T.R. Loughlin. 1991. Incidental catch of marine mammals by foreign and joint venture trawl vessels in the U.S. EEZ of the North Pacific, 1973-88. U.S. DOC, NOAA, Tech Report NMFS 104.

Peterson, M.R. 1983. Horned and Tufted Puffins. Baird, P.A. and P.J. Gould (eds.). 1983. The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. DOC, NOAA, OCSEAP Final Report 45 (1986): 401-469.

Peterson, M.R., 1983b. Common and Thick-billed Mure. Baird, P.A. and P.J. Gould (eds.). 1983. The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. DOC, NOAA, OCSEAP Final Report 45 (1986): 381-400.

Petrazzuolo, G. 1983. A review of the potential environmental effects of mineral oil used in drilling fluids. Draft Report. Technical Resources, Inc., Bethesda, MD.

Petrazzuolo, G., A.D. Michael, C.A. Menzie, H. Plugge, E.J. Zimmerman, R.G. Rolan, T.A. Mores, L.A. Smith, W.K. Parland, and S.E. Roth. 1985. Assessment of environmental fate of effects of discharges from offshore oil and gas operations. EPA 440/4-85/002. Washington, D.C. 384 pp.

Raymont, J.E.G. 1980. Plankton and productivity in the oceans. Volume 1: Phytoplankton. Pergamon Press, New York. 489 pp.

Reed, R.K. 1985. The role of wild resource use in communities of central Kenai Peninsula and Kachemak Bay, Alaska. Alaska Department of Fish and Game. Technical paper no. 106.

Reed, R.K. and P.J. Stabeno. 1993 Observations of velocity divergence in Shelikof of Strait, Alaska. Cont. Shelf Research 13(213): 225-232.

Reed, R.K., J.D. Schumacher, and L.S. Incze. 1987. Circulation in Shelikof Strait, Alaska. Jour. of Phy. Oceanography 17(9): 1546-1554.

Reed, R.K. and J.D. Schmacher. 1989. Transport and physical properties of Central Sheliko Strait, Alaska. Continental Shelf Research 9(3):261-268.

Ronov, A.B., and A.A. Yaroshevsky. 1972. Chemical composition of the earth's crust. American Geophysics Union Monograph, 13-D.

Saila, S.B., S.D. Pratt, and T.T. Polgar. 1972. Dredge spoil disposal in Rhode Island Sound. University of Rhode Island Marine Technical Report no. 2. 48 pp.

Schafer, W. 1972. Ecology and paleoecology of marine environment. G.Y. Craig (ed.). Trans. Chicago Univ. Press, Illinois. 568 pp.

Schroeder, R.F., D.B. Andersen, R. Bosworth, J.M. Morris, and J.M. Wright. 1987. Subsistence in Alaska: Arctic, Interior, Southcentral, Southwest, and Western Regional Summaries. Alaska Department of Fish and Game. Technical paper no. 150. pp. 690.

Schulenberger, E. 1970. Responses of *Gemma gemma* to a catastrophic burial. Veliger 13:163-170.

Schumacher, J.D. and A. Kendall. 1989. Fisheries oceanography coordinated investigations (FOCI). walleye pollock recruitment in the western Gulf of Alaska Proceedings of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin information update meeting, Feb 7-8, 1989. OCSEAP study MMS-89-0041.

Schumacher, J.D., P.J. Stabeno, and A.T. Roach. 1989. Volume transport in the Alaska Coastal Current. Continental Shelf Research 9(12):1071-1083.

Schumacher, J.D., W.E. Barber, B. Holt, and A.K. Liu. 1991. Satellite observations of mesoscale features in lower Cook Inlet and Shelikof Strait, Gulf of Alaska. NOAA Tech. Report ERL 445-PMEL 40.

Scientific Applications, Inc. (SAIC). 1977. Environmental assessment of the Alaskan continental shelf. Annual reports summary for the year ending March 1977. Prepared for NOAA/3LM, Boulder, CO.

Scientific Applications, Inc. (SAIC). 1979. Environmental assessment of the Alaskan continental shelf - lower Cook Inlet interim synthesis report. Prepared for NOAA/BLM, Boulder, CO. 241 pp.

Seifert, D., and L.S. Incze. 1991. Zooplankton of Stelikof Strait, Alaska, April and May 1989. Data from Fisheries Oceanography Coordinated Investigations (FOCI) cruises. Northwest Alaska Fisheries Center Report 91-16.

Sittig, M. 1985. Handbook of toxic and hazardous chemicals and carcinogens. Second Edition. Noyes Publications, Park Ridge, NJ. 950 pp.

Spallinger, A. 27 July 1993. Personal Communication (Telephone with Ms. Kimberle Stark, Tetra Tech, Inc., Redmond, WA). Alaska Dept. of Fish and Game-shellfish Division. Anchorage, AK.

Tetra Tech, Inc. 1982. Revised section 310 (h) technical support document. EPA 430/9-82-011. Prepared for U.S. Environmental Protection Agency, Office of Water Program Operations, Washington, D.C. Tetra Tech, Bellevue, WA. 223 pp.

Tetra Tech, Inc. 1993. Technical support document for the revised Offshore Operators Committee Model. Prepared for U.S. EPA, Region X. Tetra Tech, Redmond, WA. 31 pp. + appendices.

Tetra Tech, Inc. 1993b. Final Ocean Discharge Criteria evaluation for area of coverage under the Arctic NPDES general permit for oil and gas exploration OCS Lease Sales 124 and 126. Tetra Tech, Inc. Redmond, WA. 120 pp.

Tetra Tech. 1984. Technical support document for regulating dilution and deposition of drilling muds on the outer continental shelf. Prepared for U.S. Environmental Protection Agency, Region X and Jones & Stokes Associates. Tetra Tech, Inc., Bellevue, WA.

U.S. Department of Interior (U.S. DOI), Bureau of Land Management. 1981. Lower Cook Inlet-Shelikof Strait Proposed Oil and Gas Lease Sale 60. Final Environmental Impact Statement. Bureau of Land Management, Anchorage, AK.

U.S. Department of Interior. 1981. Final environmental impact statement: Lower Cook Inlet/Shelikof Strait, proposed oil and gas Lease Sale 60. BLM. 263 pp. + graphics.

U.S. Department of Interior. 1984. Gulf of Alaska/Cook Inlet lease offering (October 1984) draft environmental impact statement. Prepared by Minerals Management Service, CA. 200 pp. + appendices.

U.S. Department of Interior/Minerals Management Service (MMS). 1984. Gulf of Alaska/Cook Inlet Sale 88. Final Environmental Impact Statement. OCE EIS MMS 84-0023. U.S. DOI, MMS, Alaska OCS Region, Anchorage, AK.

U.S. Department of Interior/Minerals Management Service (MMS). 1990. Beaufort Sea planning area oil and gas Lease Sale 124. Final Environmental Impact Statement. MMS OCS EIS/EA 90-0063. USDOI, MMS, Alaska OCS Region, Anchorage, AK.

U.S. Department of Interior/Minerals Management Service (MMS). 1991. Chukchi Sea planning area oil and gas Lease Sale 126. Final Environmental Impact Statement. MMS OCS EIS/EA 90-0095. USDOI, MMS, Alaska OCS Region, Anchorage, AK.

U.S. Department of Interior/Minerals Management Service (MMS). 1992. Outer continental shelf natural gas and oil resource management, Comprehensive Program 1992-1997. Final Environmental Impact Statement. OCS EIS/EA MMS92-0004. U.S. Department of Interior, MMS, Alaska OCS Regions, Anchorage, AK.

U.S. Environmental Protection Agency (U.S. EPA). 1983. Draft Ocean Discharge Criteria Evaluation, Cook Inlet/Shelikof Strait OCS Lease Sale 60. U.S. EPA, Region X, Seattle, WA.

U.S. Environmental Protection Agency. 1984a. Draft Ocean Discharge Criteria Evaluation, Gulf of Alaska/Cook Inlet OCS Lease Sale 88. U.S. EPA, Region X, Seattle, WA.

U.S. Environmental Protection Agency. 1984b. Final ocean discharge criteria evaluation, Diapir field OCS Lease Sale 87 and state Lease Sales 39, 43, and 43a. U.S. EPA, Region X, Seattle, WA.

U.S. Environmental Protection Agency. 1985. Assessment of environmental fate and effects of discharges from offshore oil and gas operations. EPA 440/4-85/002.

U.S. Environmental Protection Agency. 1986a. Ocean discharge criteria evaluation for Norton Basin, Alaska, OCS Lease Sale 100. U.S. EPA, Region X, Seattle, WA.

U.S. Environmental Protection Agency. 1986b. Water quality criteria: Ambient aquatic life water quality criteria documents. Federal Register, 51:8361-8363.

U.S. Environmental Protection Agency. 1986c. Final general NPDES permit. Permit number AKG285000 (Cook Inlet/Guf of Alaska).

U.S. Environmental Protection Agency. 1988a. Final ocean discharge criteria evaluation for Beaufort Sea OCS oil and gas lease offering 97. U.S. EPA, Region X, Seattle, WA.

U.S. Environmental Protection Agency. 1988b. Final ocean discharge criteria evaluation for Chukchi Sea OCS oil and gas lease offering 109. U.S. EPA, Region X, Seattle, WA.

U.S. Environmental Protection Agency. 1988c. Final NPDES general permits for oil and gas operators on the outer continental shelf of Alaska; Beaufort Sea II and Chukchi Sea 53 for 37846.

U.S. Environmental Protection Agency. 1990. Draft technical support document for water quality-based toxics control. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

U.S. Environmental Protection Agency. 1992. Interim guidance on interpretation and implementation of aquatic life criteria for metals. U.S. Environmental Protection Agency, Office of Science and Technology, Health and Ecological Criteria Division, Washington, D.C.

U.S. Fish and Wildlife Service. 1992. Endangered and Threatened Wildlife and Plants: Proposed Rule to List Spectacled Eider as Threatened and Notice of 12-Month Finding for a Petition to List Two Alaskan Eiders as Endangered. U.S. Fish and Wildlife Service, Washington, D.C. Federal Register Vol 57, no. 90, Part XVII, pp. 19852-19856.

Veith, A.D. 1979. Measuring and estimating the bioconcentration factor of chemicals in fish. J. Fish. Res. Board Can. 36:1040-1048.

Vernon, G. 6 August 1993. Personal Communication (Telephone with Ms. Kimberle Stark, Tetra Tech, Inc., Redmond, WA). Lake and Peninsula Borough. King Salmon, AK.

Wapora, Inc. 1979. Lower Cook Inlet, Alaska. Environmental evaluation/impact review manual. U.S. EPA, Region 10.

Wilber, P. 1992. Case studies of the thin-layer disposal of dredged material - Fowl River, Alabama. Environmental Effects of Dredging, Vol. D-92-5. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

APPENDIX A

SUMMARY STATISTICS FROM ARCTIC OFFSHORE OIL AND GAS DISCHARGE MONITORING REPORTS

SUMMARY STATISTICS
ARCTIC OFFSHORE OIL AND GAS DISCHARGE MONITORING REPORTS (DMR's)
COMPILED: 5/20/93

FACILITY NAME; NUMBER (DMR FILENAME)	DURATION OF OPERATION		TIME INTERVAL
ARCO Cabot; AKG284102 (DMR1)	11		OCT91-AUG92
CONOCO Badami; AKG284106 (DMR2)	3		FEB92-APR92
CONOCO NW Milne; AKG284104 (DMR3)	2		FEB92-MAR92
ARCO Kuvlum #1; AKG284107 (DMR4)	3		AUG92-OCT92
SHELL Burger; AKG288002 (DMR5)	2	?	-AUG90
SHELL Crackerjack; AKG288006 (DMR6)	2		JUL91-AUG91
EXXON Thetis Island; AKG284109 (DMR7)	2		MAR93-APR93
ARCO Jones Island; AKG284108 (DMR8)	3		FEB93-APR93
ARCO Fireweed; AKG284101 (DMR9)	12		SEP90-AUG91
AMOCO Galahad; AKG284103 (DMR10)	2		SEP91-OCT91
CHEVRON Diamond; AKG288007 (DMR11)	2		SEP91-OCT91
AVERAGE VALUE=	4		

SUMMARY OF WASTESTREAM CHARACTERISTICS

7/11 actual discharges for the deck drainage wastestream;
Average of 7 = 0.2504351 mgd

9/11 actual discharge of sanitary wastestream;
3 are combined with domestic waste;
average flow for the 6 that characterize sanitary flow only: .6528918 mgd

3/11 domestic waste discharges do not include sanitary flow;
average flow of the three are .586641 mgd

7/11 actual discharges of desalination unit wastestream;
Fireweed data is suspect, therefore 6 datapoints are used for average flow;
Average flow is 0.156826 mgd

5/11 actual discharges of the blow out preventer wastestream;
average of these 5 values is .0011784 mgd

6/11 actual discharges from the boiler blowdown wastestream;
average flow from these values is .0059791 mgd

2/11 actual discharges from the fire control system test fluid wastestream;
average of these 6 values is .233551 mgd

7/11 actual discharges from the non-contact cooling water wastestream;
average of the 7 values is 2.2557051 mgd

7/11 actual discharges from the uncontaminated ballast water wastestream;
average of 7 values is 0.143838 mgd

6/11 actual discharges from the uncontaminated bilge water wastestream;
average of these 6 values is 0.0572109 mgd

8/11 actual discharges from the excess cement slurry wastestream;
7/8 useable data (Galahad is a suspect outlier);
average of 7 values = 0.2044936 mgd

6/11 actual discharges from this muds,cuttings, and cement at seafloor wastestream;
average of 6 values is 0.2161045 mgd

1/11 actual discharges for the test fluids wastestream;
maximum value is 147 barrels total volume

FACILITY	DECK DRAINAGE FLOW AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE	
ARCO Cabot; AKG284102 (DMR1)	0.002600	0.005200	0.010500	
CONOCO Badami; AKG284106 (DMR2)	0.000000	0.000000	0.000000	
CONOCO NW Milne; AKG284104 (DMR3)	0.000000	0.000000	0.000000	
ARCO Kuvium #1; AKG284107 (DMR4)	0.000256	0.000619	0.001856	
SHELL Burger; AKG288002 (DMR5)	0.012000	-	-	
SHELL Crackerjack; AKG288006 (DMR6)	0.006700	-	-	
EXXON Thetis Island; AKG284109 (DMR7)	-	0.000669	0.000669	
ARCO Jones Island; AKG284108 (DMR8)	0.000000	0.000000	0.000000	
ARCO Fireweed; AKG284101 (DMR9)	1.720000	3.580000	9.470000	<<<<
AMOCO Galahad; AKG284103 (DMR10)	0.001990	0.009650	0.016000	
CHEVRON Diamond; AKG288007 (DMR11)	0.009500	-	-	

7/11 actual discharges for the deck drainage wastestream;
Average of 7 = 0.2504351 mgd

FACILITY	SANITARY WASTE FLOW AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE		chlorine-ave minimum (mg/l)	
ARCO Cabot; AKG284102 (DMR1)	0.004950	-	-		2	S/D
CONOCO Badami; AKG284106 (DMR2)	0.005880	0.005880	0.005880		0.525	
CONOCO NW Milne; AKG284104 (DMR3)	0.003595	0.004350	0.004700		1.9	
ARCO Kuvium #1; AKG284107 (DMR4)	0.002718	0.002975	0.003037		1.5	
SHELL Burger; AKG288002 (DMR5)	0.000000	-	-		-	S/D
SHELL Crackerjack; AKG288006 (DMR6)	0.013450	-	-		1.6	S/D
EXXON Thetis Island; AKG284109 (DMR7)	0.005200	-	-		1.5	
ARCO Jones Island; AKG284108 (DMR8)	0.000000	0.000000	-		-	
ARCO Fireweed; AKG284101 (DMR9)	3.890000	5.010000	10.750000	<<<	2.55	
AMOCO Galahad; AKG284103 (DMR10)	0.009958	0.016875	0.019500		-	
CHEVRON Diamond; AKG288007 (DMR11)	0.014000	-	-		1.7	S/D

S/D = SANITARY/DOMESTIC WASTE COMINGLED

9/11 actual discharge of sanitary wastestream;
3 are combined with domestic waste;
average flow for the 6 that characterize sanitary flow only: .6528918 mgd

FACILITY	DOMESTIC WASTE FLOW AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE	
ARCO Cabot; AKG284102 (DMR1)	S/D	-	-	
CONOCO Badami; AKG284106 (DMR2)	-	-	-	
CONOCO NW Milne; AKG284104 (DMR3)	-	-	-	
ARCO Kuvium #1; AKG284107 (DMR4)	0.175573	0.349852	1.048763	
SHELL Burger; AKG288002 (DMR5)	S/D	-	-	
SHELL Crackerjack; AKG288006 (DMR6)	S/D	-	-	
EXXON Thetis Island; AKG284109 (DMR7)	0.00435	-	-	
ARCO Jones Island; AKG284108 (DMR8)	0	0	-	
ARCO Fireweed; AKG284101 (DMR9)	1.58	1.965	2.03	<---S/D FOR ALL BUT 2 MONTHS
AMOCO Galahad; AKG284103 (DMR10)	0	0		
CHEVRON Diamond; AKG288007 (DMR11)	S/D	-	-	

3/11 domestic waste discharges do not include sanitary flow;
average flow of the three are .586641 mgd

FACILITY	DESAL. UNIT FLOW		
	AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE
ARCO Cabot; AKG284102 (DMR1)	0.023500	-	-
CONOCO Badami; AKG284106 (DMR2)	-	-	-
CONOCO NW Milne; AKG284104 (DMR3)	-	-	-
ARCO Kuvlum #1; AKG284107 (DMR4)	0.862333	1.342004	1.928455
SHELL Burger; AKG288002 (DMR5)	0.023000	-	-
SHELL Crackerjack; AKG288006 (DMR6)	0.010750	-	-
EXXON Thetis Island; AKG284109 (DMR7)	-	-	-
ARCO Jones Island; AKG284108 (DMR8)	0.000000	0.000000	0.000000
ARCO Fireweed; AKG284101 (DMR9)	9.380000	17.400000	45.000000
AMOCO Galahad; AKG284103 (DMR10)	0.005873	0.051040	0.064000
CHEVRON Diamond; AKG288007 (DMR11)	0.015500	-	-

7/11 actual discharges of desalination unit wastestream;
Fireweed data is suspect, therefore 6 datapoints are used for average flow;
Average flow is 0.156826 mgd

FACILITY	BLOW OUT PREVENTER FLOW		
	AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE
ARCO Cabot; AKG284102 (DMR1)	0.000000	0.000000	0.000000
CONOCO Badami; AKG284106 (DMR2)	-	-	-
CONOCO NW Milne; AKG284104 (DMR3)	-	-	-
ARCO Kuvlum #1; AKG284107 (DMR4)	0.000092	0.000186	0.000558
SHELL Burger; AKG288002 (DMR5)	0.000113	-	-
SHELL Crackerjack; AKG288006 (DMR6)	0.000414	-	-
EXXON Thetis Island; AKG284109 (DMR7)	-	-	-
ARCO Jones Island; AKG284108 (DMR8)	0.000000	0.000000	0.000000
ARCO Fireweed; AKG284101 (DMR9)	0.004000	0.004000	0.004000
AMOCO Galahad; AKG284103 (DMR10)	0.000000	0.000000	0.000000
CHEVRON Diamond; AKG288007 (DMR11)	0.001273	-	-

5/11 actual discharges of the blow out preventer wastestream;
average of these 5 values is .0011784 mgd

FACILITY	BOILER BLOWDOWN FLOW		
	AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE
ARCO Cabot; AKG284102 (DMR1)	0.000071	-	-
CONOCO Badami; AKG284106 (DMR2)	0.0004	0.0004	0.0004
CONOCO NW Milne; AKG284104 (DMR3)	-	-	-
ARCO Kuvlum #1; AKG284107 (DMR4)	0	-	-
SHELL Burger; AKG288002 (DMR5)	0.00014	-	-
SHELL Crackerjack; AKG288006 (DMR6)	0.000132	-	-
EXXON Thetis Island; AKG284109 (DMR7)	-	-	-
ARCO Jones Island; AKG284108 (DMR8)	0	0	0
ARCO Fireweed; AKG284101 (DMR9)	0.035	0.113	1
AMOCO Galahad; AKG284103 (DMR10)	0	0	0
CHEVRON Diamond; AKG288007 (DMR11)	0.000132	-	-

6/11 actual discharges from the boiler blowdown wastestream;
average flow from these values is .0059791 mgd

FACILITY	FIRE CONTROL SYSTEM TEST FLUID FLOW		
	AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE
ARCO Cabot; AKG284102 (DMR1)	0	-	-
CONOCO Badami; AKG284106 (DMR2)	-	-	-
CONOCO NW Milne; AKG284104 (DMR3)	-	-	-
ARCO Kuvium #1; AKG284107 (DMR4)	0	-	-
SHELL Burger; AKG288002 (DMR5)	0	-	-
SHELL Crackerjack; AKG288006 (DMR6)	0.232322	-	-
EXXON Thetis Island; AKG284109 (DMR7)	-	0	0
ARCO Jones Island; AKG284108 (DMR8)	0	0	0
ARCO Fireweed; AKG284101 (DMR9)	0	0	0
AMOCO Galahad; AKG284103 (DMR10)	0	0	0
CHEVRON Diamond; AKG288007 (DMR11)	0.23478	-	-

2/11 actual discharges from the fire control system test fluid wastestream; average of these 6 values is .233551 mgd

FACILITY	NON-CONTACT COOLING WATER FLOW			
	AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE	
ARCO Cabot; AKG284102 (DMR1)	1.286508	-	-	
CONOCO Badami; AKG284106 (DMR2)	-	-	-	
CONOCO NW Milne; AKG284104 (DMR3)	-	-	-	
ARCO Kuvium #1; AKG284107 (DMR4)	3.598415	4.297266	5.177928	
SHELL Burger; AKG288002 (DMR5)	1.85	-	-	<-ONE VALUE
SHELL Crackerjack; AKG288006 (DMR6)	2.4522	-	-	
EXXON Thetis Island; AKG284109 (DMR7)	0	-	-	
ARCO Jones Island; AKG284108 (DMR8)	0	0	0	
ARCO Fireweed; AKG284101 (DMR9)	2.917113	2.9171581	5	
AMOCO Galahad; AKG284103 (DMR10)	0.8907	1.205	1.33	
CHEVRON Diamond; AKG288007 (DMR11)	2.795	-	-	

7/11 actual discharges from the non-contact cooling water wastestream; average of the 7 values is 2.2557051 mgd

FACILITY	UNCONTAMINATED BALLAST WATER FLOW			
	AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE	
ARCO Cabot; AKG284102 (DMR1)	0.51266	-	-	
CONOCO Badami; AKG284106 (DMR2)	-	-	-	
CONOCO NW Milne; AKG284104 (DMR3)	-	-	-	
ARCO Kuvium #1; AKG284107 (DMR4)	0.045952	0.079251	0.237754	
SHELL Burger; AKG288002 (DMR5)	0.001	-	-	<---ONE VALUE
SHELL Crackerjack; AKG288006 (DMR6)	0.0262	-	-	
EXXON Thetis Island; AKG284109 (DMR7)	-	-	-	
ARCO Jones Island; AKG284108 (DMR8)	0	0	0	
ARCO Fireweed; AKG284101 (DMR9)	0.42	0.42	5	
AMOCO Galahad; AKG284103 (DMR10)	0.0005555	0.005	0.01	
CHEVRON Diamond; AKG288007 (DMR11)	0.0005	-	-	

7/11 actual discharges from the uncontaminated ballast water wastestream; average of 7 values is 0.143838 mgd

FACILITY	UNCONTAMINATED BILGE WATER FLOW AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE	
ARCO Cabot; AKG284102 (DMR1)	0.0005	-	-	
CONOCO Badami; AKG284106 (DMR2)	-	-	-	
CONOCO NW Milne; AKG284104 (DMR3)	-	-	-	
ARCO Kuvlum #1; AKG284107 (DMR4)	0.005832	0.023828	0.067662	
SHELL Burger; AKG288002 (DMR5)	0.002047	-	-	<--ONE VALUE
SHELL Crackerjack; AKG288006 (DMR6)	0.000132	-	-	
EXXON Thetis Island; AKG284109 (DMR7)	-	-	-	
ARCO Jones Island; AKG284108 (DMR8)	0	0	0	
ARCO Fireweed; AKG284101 (DMR9)	0.334	0.365	1.32	
AMOCO Galahad; AKG284103 (DMR10)	0.0007545	0.0034	0.0068	
CHEVRON Diamond; AKG288007 (DMR11)	0	-	-	

6/11 actual discharges from the uncontaminated bilge water wastestream; average of these 6 values is 0.0572109 mgd

FACILITY	EXCESS CEMENT SLURRY FLOW AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE	
ARCO Cabot; AKG284102 (DMR1)	0.0015	-	-	
CONOCO Badami; AKG284106 (DMR2)	-	0	0	
CONOCO NW Milne; AKG284104 (DMR3)	0.13015	4.2004	8.4	
ARCO Kuvlum #1; AKG284107 (DMR4)	0	0	0	
SHELL Burger; AKG288002 (DMR5)	0.000105	-	-	<--ONE VALUE
SHELL Crackerjack; AKG288006 (DMR6)	0.17	-	-	
EXXON Thetis Island; AKG284109 (DMR7)	0.00165	-	-	
ARCO Jones Island; AKG284108 (DMR8)	0	0	0	
ARCO Fireweed; AKG284101 (DMR9)	1.127	1.5505	12.6	
AMOCO Galahad; AKG284103 (DMR10)	6.5	85	170	
CHEVRON Diamond; AKG288007 (DMR11)	0.00105	-	-	

8/11 actual discharges from the excess cement slurry wastestream; 7/8 useable data (Galahad is a suspect outlier); average of 7 values = 0.2044936 mgd

FACILITY	MUDS,CUTTINGS AND CEMENT AT SEAFLOOR FLOW AVE (OF AVE)	AVE (OF MAX)	HIGHEST VALUE	
ARCO Cabot; AKG284102 (DMR1)	0.001768	-	-	
CONOCO Badami; AKG284106 (DMR2)	-	-	-	
CONOCO NW Milne; AKG284104 (DMR3)	-	-	-	
ARCO Kuvlum #1; AKG284107 (DMR4)	0.005719	0.006438	0.019314	
SHELL Burger; AKG288002 (DMR5)	0.015	-	-	<--ONE VALUE
SHELL Crackerjack; AKG288006 (DMR6)	-	-	-	
EXXON Thetis Island; AKG284109 (DMR7)	-	-	-	
ARCO Jones Island; AKG284108 (DMR8)	0	0	0	
ARCO Fireweed; AKG284101 (DMR9)	1.134	2.0895	25.074	<--OUTLIER?
AMOCO Galahad; AKG284103 (DMR10)	0.00214	0.0009575	0.001915	
CHEVRON Diamond; AKG288007 (DMR11)	0.138	- -	-	

6/11 actual discharges from this muds,cuttings, and cement at seafloor wastestream; average of 6 values is 0.2161045 mgd

FACILITY	TEST FLUID FLOW VOL (BBL) AVE	
ARCO Cabot; AKG284102 (DMR1)	0	
CONOCO Badami; AKG284106 (DMR2)	-	
CONOCO NW Milne; AKG284104 (DMR3)	-	
ARCO Kuvlum #1; AKG284107 (DMR4)	74	147
SHELL Burger; AKG288002 (DMR5)	-	
SHELL Crackerjack; AKG288006 (DMR6)	-	
EXXON Thetis Island; AKG284109 (DMR7)	-	
ARCO Jones Island; AKG284108 (DMR8)	0	
ARCO Fireweed; AKG284101 (DMR9)	0	
AMOCO Galahad; AKG284103 (DMR10)	0	
CHEVRON Diamond; AKG288007 (DMR11)	-	

1/11 actual discharges for the test fluids wastestream; maximum value is 147 barrels total volume

DRILLING FLUIDS AND CUTTINGS AND WASHWATER	VOL(BBL/OPERATION)	
ARCO Cabot; AKG284102 (DMR1)	40559.00	
CONOCO Badami; AKG284106 (DMR2)	33492.00	
CONOCO NW Milne; AKG284104 (DMR3)	9019.00	
ARCO Kuvlum #1; AKG284107 (DMR4)	4913.00	
SHELL Burger; AKG288002 (DMR5)	8684.00	<-ONE MONTH OF DMR
SHELL Crackerjack; AKG288006 (DMR6)	4575.00	
EXXON Thetis Island; AKG284109 (DMR7)	8425.00	
ARCO Jones Island; AKG284108 (DMR8)	3641.00	
ARCO Fireweed; AKG284101 (DMR9)	3264.00	
AMOCO Galahad; AKG284103 (DMR10)	13968.00	
CHEVRON Diamond; AKG288007 (DMR11)	13454.00	
AVERAGE TOTAL VOL=	13090.36	

APPENDIX B

COMMON AND SCIENTIFIC NAMES OF SPECIES LOCATED IN OR ADJACENT TO THE COOK INLET PLANNING AREA

COMMON AND SCIENTIFIC NAMES OF SPECIES LOCATED IN OR ADJACENT TO THE COOK INLET PLANNING AREA (Page 1 of 2)	
COMMON NAME	**SCIENTIFIC NAME**
Fish	
Capelin	*Mallotus villosus*
Chinook salmon (king)	*Oncorhynchus tschawytscha*
Chum salmon (dog)	*Oncorhynchus keta*
Coho salmon (silver)	*Oncorhynchus kisutch*
Cutthroat trout	*Salmo clarki*
Dolly Varden	*Salvelinus malma*
Halibut	*Hippoglossus stenolepis*
Pacific herring	*Clupea harengus pallasi*
Lake trout	*Salvelinus namaycush*
Pacific cod	*Gadus macrocephalus*
Pink salmon (humpback)	*Oncorhynchus gorbuscha*
Walleys pollock	*Theragra chalcogramma*
Rainbow trout	*Oncorhynchus mykiss*
Rockfish	*Sebastes alutus*
Sablefish	*Anoplopoma fimbria*
Sand lance	*Ammodytes hexapterus*
Sockeye salmon (red)	*Oncorhynchus nerka*
Steelhead trout	*Salmo gairdneri*
Yellowfin sole	*Limanda aspara*
Invertebrates	
Dungeness crab	*Cancer magister*
Red king crab	*Paralithodes camtschatica*
Tanner crab	*Chionoecetes bairdi*
Razor clam	*Siliqua patula*
Humpback shrimp	*Pandalus goniurus*
Pink shrimp	*Pandalus borealis*
Marine Mammals	
Pinnipeds	
Harbor seal	*Phoca vitulina*
Steller sea lion	*Eunetopias jubatus*
Northern fur seal	*Callorhinus ursinus*
Mustelid	
Sea otter	*Enhydra lutris*
Cetaceans	
Beluga whale	*Delphinapterus leucas*
Fin whale	*Balaenoptera physalus*
Gray whale	*Eschrichtius robustus*
Humpback whale	*Megaptera novaeagliae*
Killer whale	*Orcinus orca*
Minke whale	*Balaenoptera acutorostrata*
Sei whale	*Balaenoptera horealis*
Dall's porpoise	*Phocoenoides dalli*
Harbor porpoise	*Phocoena phocoena*

COMMON AND SCIENTIFIC NAMES OF SPECIES LOCATED IN OR ADJACENT TO THE COOK INLET PLANNING AREA (Page 2 of 2)	
COMMON NAME	**SCIENTIFIC NAME**
Marine Birds	
Black-legged kittiwake	*Rissa tridactyla*
Double-crested cormorant	*Phalacrocorax auritus*
Common murre	*Uria lomvia*
Fork-tailed storm petrel	*Oceandroma funcata*
Horned puffin	*Fratercula corniculata*
Leach's storm petrel	*Oceanodroma leucorhoa*
Glaucous-winged gull	*Larus glaucescens*
Thick-billed murre	*Uria algae*
Tufted puffin	*Lunda cirrhata*
Sooty shearwater	*Puffinus tenuirostris*
Pelagic cormorant	*Phalacrocorax pelagicus*
Red-face cormorant	*Pholacroax urile*
Northern fulmar	*Fulmarus glacialis*
Waterfowl	
American widgeon	*Anas americana*
Black scoter	*Melanitta nigra*
Aleutian Canada goose	*Branta canadensis leucopareia*
Canada goose	*Branta canadensis*
Greater scaup	*Aythya marila*
Oldsquaw	*Clangula hyemalis*
White-winged scoter	*Melanitta deglandi*
Surf scoter	*Melanitta perspicillata*
Steller's eider	*Polysticta stelleri*
Tule white fronted goose	*Anser albifrons elgdsi*
Pigeon guillemot	*Cepphus columba*
Marbled murrelet	*Brachyramphus marmoratus*
Crested auklet	*Aethia cristatella*
Other birds	
American peregrine falcon	*Falco peregrinus anatum*
Arctic peregrine falcon	*Falco peregrinus tundrius*

APPENDIX C

U.S. EPA, REGION X USED MUD 96-HR LC50s FOR *MYSIDOPSIS BAHIA*

U.S. EPA, Region X Used Mud 96-Hr LC50s for Mysidopsis Bahia

PMTNO	OPNAME	WELLNAME	LC50	UNITS	TOXTYPE	TOXCITE	TOXDATE1	TOXDATE2	BASEMUD
AKG284010	AMERADA HESS	NORTH STAR A, #2	840	PPM SPP WMB	USED/PILL	EHA 6/88 #900740	4/2/88	SAMPLE	
AKG285004	AMOCO	ANNA 13RD	100000	PPM SPP	USED/EOW	ESE 4/88 #86-335	6/13/87	RECEIVED	Cl2
AKG285004	AMOCO	ANNA, 32RD		pH TOO LOW	USED/PILL	ESE 4/88 #86-335 (MUD 4)	9/28/87	SAMPLED	Cl2
AKG285004	AMOCO	ANNA, 32RD	0	TOO LITTLE MUD	USED	ESE 4/88 #86-335 (MUD 2)	9/24/87	SAMPLED	Cl2
AKG285004	AMOCO	ANNA, 32RD	26000	PPM SPP	USED/PILL	ESE 4/88 #86-335 (MUD 5)	9/26/87	SAMPLED	Cl2
AKG285004	AMOCO	ANNA, 32RD	48000	PPM SPP	USED	ESE 4/88 #86-335 (MUD 1)	8/10/87	SAMPLE	Cl2
AKG285004	AMOCO	ANNA, 32RD	63000	PPM SPP	USED/EOW	ESE 4/88 #86-335 (MUD 6)	10/17/87	SAMPLED	Cl2
AKG285004	AMOCO	ANNA, 32RD	65000	PPM SPP	USED/PILL	ESE 4/88 #86-335 (MUD 3)	9/22/87	SAMPLED	Cl2
AKG285004	AMOCO	ANNA, GP1 [illegible]		DRAFT		ESE 4/88 #86-335			
AKG284015	AMOCO	BELCHER #1, OCS-Y-0917('88)	79000	PPM SPP	USED/EOW/NGM	ESE 2/89 #86-335	10/26/88	SAMPLED	KCl/Al/POLY
AKG284015	AMOCO	BELCHER #1, OCS-Y-0917('88)	82500	PPM SPP	USED/NGM	ESE 2/89 #86-335	10/2/88	SAMPLED	KCl/Al/POLY
AKG284015	AMOCO	BELCHER #1, OCS-Y-0917('88)	87000	PPM SPP	USED/NGM	ESE 2/89 #86-335	10/12/88	SAMPLED	KCl/Al/POLY
AKG284015	AMOCO	BELCHER #1, OCS-Y-0917('88)	102000	PPM SPP	USED/NGM	ESE 2/89 #86-335	10/2/88	SAMPLED	KCl/Al/POLY
AKG284015	AMOCO	BELCHER, OCS-Y-0917 ('89)	68500	PPM SPP	EOW/NGM	ENSR 9/20 EN89267/MI#1383	8/29/89	SAMPLE	KCl/Al SULF
AKG284015	AMOCO	BELCHER, OCS-Y-0917, #1('89)	70600	PPM SPP	EOW/NGM	ENSR 8/18/89 EN89217	8/2/89	SAMPLE	KCl/Al SULF
AKG284015	AMOCO	BELCHER, OCS-Y-0917, #2('89)	75000	PPM SPP	EOW/NGM	ENSR 8/18/89 EN89218	8/2/89	SAMPLE	KCl/Al SULF
AKG285006	AMOCO	BRUCE, GRANITE POINT 17587 #6	1000000	PPM SPP	USED/EOW	WA/CORE LAB #900204 2/90	1/23/90	SAMPLE	Cl2
AKG283010	AMOCO	DANIELLE #1	860000	PPM SPP	USED/NGM	ESE 1/86 #85-353 (MUD 3)	9/27/85	RECEIPT	K LIME
AKG284103	AMOCO	GALAHAD #1	792629	PPM SPP	USED/EOW/INT	AEL 10/26/91 Q10438	10/12/91	SAMPLE	Cl2 +SP-101
AKG284103	AMOCO	GALAHAD #1	851140	PPM SPP	USED/EOW	AEL 10/26/91 Q10387	10/12/91	SAMPLE	Cl2
AKG283020	AMOCO	GEORGE #1	29800	MG/L SPP	USED/NGM	ESE 1/86 #85-353 (MUD 1)	9/27/85	RECEIPT	K LIME
AKG283018	AMOCO	MISHA #1	80000	PPM SPP	USED/NGM	ESE 1/86 #85-353 (MUD 2)	9/27/85	RECEIPT	K LIME
AKG283021	AMOCO	NANCY #1	340000	PPM SPP	USED/NGM	ESE 1/86 #85-353 (MUD 5)	10/29/95	RECEIPT	K LIME
AKG283009	AMOCO	NICHOLE #1	860000	PPM SPP	USED/NGM	ESE 1/86 #85-353 (MUD 4)	9/27/85	RECEIPT	K LIME
AKG284008	AMOCO	SANDPIPER #2	100000	PPM SPP	USED	ESE 9/86 #86-335	6/18/86	SAMPLE	NI (8)
AKG284008	AMOCO	SANDPIPER #2	640000	PPM SPP	USED	ESE 7/86 #86-335	4/18/86	RECEIPT	NI
AKG285021	ARCO	ADRIATIC VIII (STURGEON #1)	1000000	PPM SPP	USED/EOW	WA/CORE LAB #902101 10/90	10/7/90	SAMPLE	Cl2
AKG284101	ARCO	FIREWEED #1	1000000	PPM SPP	USED/EOW	ENSR, ES1582	12/10/90	SAMPLE	2
AKG284101	ARCO	FIREWEED #1	1000000	PPM SPP	USED/INTERIM	ENSR, ES1565	11/9/90	RECEIVED	2 17.5"
AKG285008	ARCO	KING SALMON, K6 RD	2704	PPM SPP	USED/EOW	WEINTRITT, 033-12-6591	7/1/88	SAMPLE	Cl2
AKG285008	ARCO	KING SALMON, K6 RD	11456	PPM SPP	USED/PILL	WEINTRITT, 033-12-6562	6/12/88	SAMPLE	Cl2 W/PILL 2
AKG285008	ARCO	KING SALMON, K6 RD	32038	PPM SPP	USED/PILL	WEINTRITT, 033-12-6561	6/14/88	SAMPLE	Cl2 W/PILL 3
AKG285008	ARCO	KING SALMON, K6 RD	51182	PPM SPP	USED/PILL	WEINTRITT, 033-12-6508	5/27/88	RECEIVED	Cl2 W/PILL 1
AK-003866-1	BP, ENDICOTT	MPI, K-16 (65677-001)	1000000	PPM SPP	1ST QTR			2/14/89	
AK-003866-1	BP, ENDICOTT	MPI, M-19 (61546-02)	671000	PPM SPP	USED/EOW	*NO REPORT SUBMITTED?	6/4/86	SAMPLE	7
AK-003866-1	BP, ENDICOTT	MPI, N-22 (63518-01)	1000000	PPM SPP	USED/EOW	RMAL/ENSECO 6/87	4/30/87	SAMPLE	7
AK-003866-1	BP, ENDICOTT	MPI, P-12 (626820)	1000000	PPM SPP	4TH QTR			12/10/88	
AK-003866-1	BP, ENDICOTT	MPI, P-18 (001270-000)	1000000	PPM SPP	3RD QTR			9/14/88	
AK-003866-1	BP, ENDICOTT	MPI, P-20 (62772-01)	313000	PPM SPP	USED/EOW	RMAL/ENSECO 4/87	2/6/87	SAMPLE	7
AK-003866-1	BP, ENDICOTT	MPI, Q-17 (62240-02)	366000	PPM SPP	USED/EOW	RMAL/ENSECO 4/87	10/16/86	SAMPLE	7
AK-003866-1	BP, ENDICOTT	MPI, Q16 (90S911)	1000000		1ST QTR			3/18/88	
AK-003866-1	BP, ENDICOTT	MPI, R-25 (67060-001)	846500		2ND QTR			[illegible]	
AK-003866-1	BP, ENDICOTT	MPI, UNKNOWN (65260-001)	1000000		4TH QTR			12/30/87	
AK-003866-1	BP, ENDICOTT	SDI, J-88 (65236-001)	1000000		4TH QTR			11/13/87	
AK-003866-1	BP, ENDICOTT	SDI, K-39 (626827)	1000000		4TH QTR			12/15/88	
AK-003866-1	BP, ENDICOTT	SDI, L-28 (65566-002)	1000000		1ST QTR			2/1/89	
AK-003866-1	BP, ENDICOTT	SDI, L-36 (67149-001)	1000000		2ND QTR			4/14/89	
AK-003866-1	BP, ENDICOTT	SDI, L-34 (63496-01)	992000	PPM SPP	USED/EOW	RMAL/ENSECO 6/87	4/26/87	SAMPLE	7
AK-003866-1	BP, ENDICOTT	SDI, M-33 (61704-02)	106000	PPM SPP	USED/EOW	RMAL/ENSECO 5/87	7/3/86	SAMPLE	7

U.S. EPA, Region X Used Mud 96-Hr LC50s for Mysidopsis Bahia

PMTNO	OPNAME	WELLNAME	PILLCITE	BIOREQ	BBLDISCH
AKG284010	AMERADA HESS	NORTH STAR A. #2	HALLIBURTON/GM60+M28 NO DISCHARGE		
AKG285004	AMOCO	ANNA 13RD			
AKG285004	AMOCO	ANNA, 32RD	KWIKSPOT/VISTA ODC #2, CIRCULATED		
AKG285004	AMOCO	ANNA, 32RD			
AKG285004	AMOCO	ANNA, 32RD	KWIKSPOT/VISTA ODC #3, CIRCULATED		
AKG285004	AMOCO	ANNA, 32RD			
AKG285004	AMOCO	ANNA, 32RD			
AKG285004	AMOCO	ANNA, 32RD	KWIKSPOT/VISTA ODC #1, CIRCULATED, LOW pH.		
AKG285004	AMOCO	ANNA, GP18742 [illegible]			
AKG284015	AMOCO	BELCHER #1, OCS-Y-0917('88)	NONE	NONGENERIC MUD	
AKG284015	AMOCO	BELCHER #1, OCS-Y-0917('88)	NONE	NONGENERIC MUD	
AKG284015	AMOCO	BELCHER #1, OCS-Y-0917('88)	NONE	AT MAX PRODUCT CONC	
AKG284015	AMOCO	BELCHER #1, OCS-Y-0917('88)	NONE	NONGENERIC MUD	
AKG284015	AMOCO	BELCHER, OCS-Y-0917 ('89)	NONE	INTERIM MUD AUTH	
AKG284015	AMOCO	BELCHER, OCS-Y-0917, #1('89)	NONE	INTERIM AUTH OF MUD	
AKG284015	AMOCO	BELCHER, OCS-Y-0917, #2('89)	NONE	INTERIM AUTH OF MUD	
AKG285006	AMOCO	BRUCE, GRANITE POINT 17587 #6	NONE	EOW	
AKG283010	AMOCO	DANIELLE #1			
AKG284103	AMOCO	GALAHAD #1	NONE	MAX AUTH OF SP-101	
AKG284103	AMOCO	GALAHAD #1	NONE	EOW	
AKG283020	AMOCO	GEORGE #1			
AKG283018	AMOCO	MISHA #1			
AKG283021	AMOCO	NANCY #1			
AKG283009	AMOCO	NICHOLE #1			
AKG284008	AMOCO	SANDPIPER #2		ON PILL	
AKG284008	AMOCO	SANDPIPER #2		ON PILL	
AKG285021	ARCO	ADRIATIC VIII (STURGEON #1)	NONE	EOW	11749
AKG284101	ARCO	FIREWEED #1	NONE	EOW	12105
AKG284101	ARCO	FIREWEED #1	NONE	END-OF-INTERVAL	5948
AKG285008	ARCO	KING SALMON, K6 RD	NONE	EOW	
AKG285008	ARCO	KING SALMON, K6 RD	EZ-SPOT	ON PILL #2	
AKG285008	ARCO	KING SALMON, K6 RD	EZ-SPOT	ON PILL #3	
AKG285008	ARCO	KING SALMON, K6 RD	EZ-SPOT	ON PILL #1.	
AK-003866-1	BP, ENDICOTT	MPI, K-16 (65677-001)			
AK-003866-1	BP, ENDICOTT	MPI, M-19 (61546-02)			
AK-003866-1	BP, ENDICOTT	MPI, N-22 (63518-01)			
AK-003866-1	BP, ENDICOTT	MPI, P-13 (626820)			
AK-003866-1	BP, ENDICOTT	MPI, P-19 (001270-000)			
AK-003866-1	BP, ENDICOTT	MPI, P-20 (62772-01)			
AK-003866-1	BP, ENDICOTT	MPI, Q-17 (62240-02)			
AK-003866-1	BP, ENDICOTT	MPI, Q16 (803911)			
AK-003866-1	BP, ENDICOTT	MPI, R-26 (67080-001)			
AK-003866-1	BP, ENDICOTT	MPI, UNKNOWN (65380-001)			
AK-003866-1	BP, ENDICOTT	SDI, J-39 (65138-001)			
AK-003866-1	BP, ENDICOTT	SDI, K-39 (826827)			
AK-003866-1	BP, ENDICOTT	SDI, L-28 (66596-002)			
AK-003866-1	BP, ENDICOTT	SDI, L-28 (67143-001)			
AK-003866-1	BP, ENDICOTT	SDI, L-34 (63496-01)			
AK-003866-1	BP, ENDICOTT	SDI, M-33 (61704-02)			

U.S. EPA, Region X Used Mud 96-Hr LC50s for Mysidopsis Bahia

PMTNO	OPNAME	WELLNAME	LC50	UNITS	TOXTYPE	TOXCITE	TOXDATE1	TOXDATE2	BASEMUD
[illegible]	[illegible]	[illegible]	1000000		1ST QTR			[illegible]	
AK-003866-1	BP, ENDICOTT	SDI, N-29 (62703-01)	174000	PPM SPP	USED/EOW	RMAL/ENSECO 4/87	1/26/87	SAMPLE	7
AK-003866-1	BP, ENDICOTT	SDI, N-32 (62060-02)	140000	PPM SPP	USED/EOW	RMAL/ENSECO 4/87	9/15/86	SAMPLE	NI
[illegible]	[illegible]	[illegible]	1000000		3RD QTR			[illegible]	
AKG284001	EXXON	CIDS SITE 1, #2	283600	PPM SPP	USED	ERCO 3/86	3/8/86	RECEIPT	8
AKG284001	EXXON	CIDS SITE 1, #1	100000	WME	USED/PILL	EHA/MI 12/84 #841025	12/13/84	TEST DATE	5 11/3/84
AKG284001	EXXON	CIDS SITE 1, #1	100000	WME	USED/PILL	EHA/MI 12/84 #841025	12/13/84	TEST DATE	5 11/7/84
[illegible]	[illegible]	[illegible]	0	NO LC50/PARTIAL TEST	USED/EOW	BATTELLE 11/86 #AR-01/02	7/22/86	SAMPLE	[illegible]
[illegible]	[illegible]	[illegible]	7	PPM SPP WME	ESTIMATED	ALL + PILL			[illegible]
[illegible]	EXXON	[illegible]	18	PPM SPP WME	ESTIMATED	ALL ADDITIVES			[illegible]
[illegible]	EXXON	[illegible]	0	NO LC50/PARTIAL TEST	USED/EOW	[illegible]	[illegible]	SAMPLE	[illegible]
[illegible]	EXXON	[illegible]	0	NO LC50/PARTIAL TEST	USED/EOW	[illegible]	[illegible]	SAMPLE	[illegible]
AKG285009	MARATHON	DOLLY VARDEN, D-30RD #2	138588	PPM SPP	USED/PILL	WEINTRITT, 033-12-6880	10/12/88	SAMPLE	CI2 W/PILL
AKG285009	MARATHON	DOLLY VARDEN, D-30RD #2	885382	PPM SPP	USED/EOW	WEINTRITT, 033-12-7060	12/19/88	SAMPLE	C12
AKG285009	MARATHON	DOLLY VARDEN, D-30RD #2	1000000	PPM SPP	USED/PILL	WEINTRITT, 033-12-6956	11/4/88	SAMPLE	CI2 W/MO
AKG285009	MARATHON	DOLLY VARDEN, D-45	1000000	PPM SPP	USED/EOW	ABL 7/3/89 #890627-1	6/27/89	TEST DATE	CI2
AKG285009	MARATHON	DOLLY VARDEN, D-46	1000000	PPM SPP	USED/EOW	ABL 4/10/90 #900402-1	3/30/90	SAMPLE	CI2
AKG285019	MARATHON	STEELHEAD, M-1	52800	PPM SPP	USED/EOW/NGM	ABL 7/17/87 #870706-4	6/29/87	SAMPLE	POLY PLUS K
AKG285019	MARATHON	STEELHEAD, M-1	64500	PPM SPP	USED/NGM	ABL 7/17/87 #870706-6	6/22/87	SAMPLE	POLY PLUS K
AKG285019	MARATHON	STEELHEAD, M-1	109000	PPM SPP	USED/EOW/NGM	ABL 7/17/87 #870706-5	7/15/87	SAMPLE	POLY PLUS K
AKG285019	MARATHON	STEELHEAD, M-2	197928	PPM SPP	USED/NGM	EHA/MI 9/21/87 #82687-1	8/26/87	SAMPLE	POLY PLUS K
AKG285019	MARATHON	STEELHEAD, M-3	1000000	PPM SPP	USED EOW	ABL 8/10/90 #900803-3	7/29/90	SAMPLE	CI2
AKG285019	MARATHON	STEELHEAD, M-5	1000000	PPM SPP	USED/EOW	ENSR SAMPLE EN90121	2/28/90	SAMPLE	CI2 W/PHPA
AKG285019	MARATHON	STEELHEAD, M-13	1000000	PPM SPP	USED/EOW/NGM	ENSR SAMPLE EN89326	10/2/89	SAMPLE	POLY PLUS G
AKG285019	MARATHON	STEELHEAD, M-14	1000000	PPM SPP	USED/EOW	ENSR SAMPLE EN89423	12/11/89	SAMPLE	POLY PLUS G
AKG285019	MARATHON	STEELHEAD, M-15	1000000	PPM SPP	USED/EOW	ABL 10/29/90 #901023-1	10/16/90	SAMPLE	POLY PLUS G
[illegible]	MARATHON	[illegible]	[illegible]	PPM SPP	[illegible]	[illegible]	[illegible]	SAMPLE	[illegible]
AKG285019	MARATHON	STEELHEAD, M-25	12076	PPM SPP	USED/PILL/EOW	EHA/MI 12/2/87	11/24/87	SAMPLE	POLY PLUS K
AKG285019	MARATHON	STEELHEAD, M-25	280267	PPM SPP	USED/PILL/NGM	EHA/MI 12/9/87 #ES-1142	11/11/87	SAMPLE	POLY PLUS K
AKG285019	MARATHON	STEELHEAD, M-26 RELIEF	1000000	PPM SPP	USED/EOW	EHA 08/88 #880544	7/22/88	SAMPLE	CI2
AKG285019	MARATHON	STEELHEAD, M-27	1000000	PPM SPP	USED/EOW	ANALYTIKEM #ES-1605	1/26/91	SAMPLE	CI2
AKG285019	MARATHON	STEELHEAD, M-28	5062	PPM SPP	USED/EOW	ENSR SAMPLE EN90262	5/29/90	SAMPLE	CI2
AKG285019	MARATHON	STEELHEAD, M-29	1000000	PPM SPP	USED/EOW	ANALYTIKEM #ES-1672	6/24/91	SAMPLE	CI2
AKG285012	SWEPI	A, A23-01RD	1000000	PPM SPP	USED/EOW	ABL 12/22/87 #871216-3	12/7/87	SAMPLE	CI2
AKG288002	SWEPI	BURGER #1, OCS-Y 1413	719000	PPM SPP	USED/EOW	ABL 8/27/90 #900822-1	8/17/90	SAMPLE	2
AKG288002	SWEPI	BURGER #1, OCS-Y 1413	1000000	PPM SPP	USED/EOW	ABL 10/17/89 #891009-2	10/4/89	SAMPLE	2
AKG288002	SWEPI	BURGER #1, OCS-Y 1413	308112	PPM SPP	USED/NGM	ABL 10/2/89 #890922-1	9/18/89	SAMPLE	NGM
AKG285013	SWEPI	C, C11-23	1000000	PPM SPP	USED/EOW	ABL 5/23/91 #910515-1	5/12/91	SAMPLE	CI2
AKG285013	SWEPI	C, C12-23	1000000	PPM SPP	USED/EOW	ABL 5/29/90 900523-1	5/18/90	SAMPLE	KCL2
AKG285013	SWEPI	C, C13-23	476324	PPM SPP	USED/EOW	ABL 10/14/88 #881007-1			CI2
AKG285013	SWEPI	C, C13A-23	1000000	PPM SPP	USED/EOW	ABL 1/4/91 #901227-1	12/21/90	SAMPLE	CI2
AKG285013	SWEPI	C, C21-23	457943	PPM SPP	USED/NGM	ABL 01/02/90 #891227-1	12/14/89		KCI2
AKG285013	SWEPI	C, C21-26	266380	PPM SPP	USED/EOW	ABL 5/30/89 #890519-1			CI2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AKG285013	SWEPI	C, C21A-23	320000	PPM SPP	USED/EOW	ABL 7/31/91 #910719-1	7/18/91	SAMPLE	CI2
AKG285013	SWEPI	C, C22-23	156190	PPM SPP	USED/EOW	ABL, 6/22/88, #880621-2	6/15/88	SAMPLE	CI2
AKG285013	SWEPI	C, C24A-14	346180	PPM SPP	USED/EOW	ABL 3/21/88 #880321-2	3/18/88	SAMPLE	CI2
AKG285013	SWEPI	C, C24A-23	593900	PPM SPP	USED/EOW	ABL 9/2/88 #880825-1	8/25/88	SAMPLE	CI2
AKG285013	SWEPI	C, C41-26	623888	PPM SPP	USED/EOW/NGM	ABL 09/19/89 #890913-1	9/10/89		KCI2

U.S. EPA, Region X Used Mud 96-Hr LC50s for Mysidopsis Bahia

PMTNO	OPNAME	WELLNAME	PILLCITE	BIOREQ	BBLDISCH
AK-003866-1	BP, ENDICOTT	SDI, N-28 (602467)			
AK-003866-1	BP, ENDICOTT	SDI, N-29 (62703-01)			
AK-003866-1	BP, ENDICOTT	SDI, N-32 (62060-02)			
AK-003866-1	BP, ENDICOTT	SDI, O-34 (001232-000)			
AKG284001	EXXON	CIDS SITE 1, #2	RESINEX INADVERTANT USE		
AKG284001	EXXON	CIDS SITE 1, #1	BEFORE ADDING BEN-EX	WITH PILL	
AKG284001	EXXON	CIDS SITE 1, #1	AFTER ADDING BEN-EX	WITH PILL	
AKG287001	EXXON	OCS-Y-0366, #1		WITH PILL	
AKG287001	EXXON	OCS-Y-0280, #1	EZ SPOT/MENTOR28		
AKG287001	EXXON	OCS-Y-0866, #1	NO PILL IN THIS VALUE		
AKG287002	EXXON	OCS-Y-0407, #1		?	
AKG287006	EXXON	OCS-Y-0426, #1		?	
AKG285009	MARATHON	DOLLY VARDEN, D-30RD #2	EZ SPOT WITH KEROSENE, NO MUD INVENTORY	WITH PILL	
AKG285009	MARATHON	DOLLY VARDEN, D-30RD #2	NONE	EOW	352
AKG285009	MARATHON	DOLLY VARDEN, D-30RD #2	MINERAL OIL CARRIER	WITH PILL	
AKG285009	MARATHON	DOLLY VARDEN, D-45	NONE	EOW	10927
AKG285009	MARATHON	DOLLY VARDEN, D-46	NONE	EOW	8184
AKG285019	MARATHON	STEELHEAD, M-1		ON MUD,ADD,&PILL	
AKG285019	MARATHON	STEELHEAD, M-1		ON MUD,ADD,&PILL	
AKG285019	MARATHON	STEELHEAD, M-1		ON MUD,ADD & PILL	
AKG285019	MARATHON	STEELHEAD, M-2		ON MUD,ADD,&PILL	
AKG285019	MARATHON	STEELHEAD, M-3	NONE	EOW	2568
AKG285019	MARATHON	STEELHEAD, M-5	NONE	EOW	3148
AKG285019	MARATHON	STEELHEAD, M-13	NONE	EOW	6215
AKG285019	MARATHON	STEELHEAD, M-14	NONE	EOW	6604
AKG285019	MARATHON	STEELHEAD, M-15	NONE	EOW	6598
AKG285019	MARATHON	STEELHEAD, M-25	NO DISCHARGE! KWIKSPOT IN RECOVERED MUD	ON MUD,ADD & PILL	
AKG285019	MARATHON	STEELHEAD, M-25	KWIKSPOT AFTER ~ 50% PILL REMOVAL	MUD,ADD & PILL	
AKG285019	MARATHON	STEELHEAD, M-25	MUD PRIOR TO KWIKSPOT USE	ON MUD,ADD & PILL	
AKG285019	MARATHON	STEELHEAD, M-26 RELIEF	NONE	EOW	4883
AKG285019	MARATHON	STEELHEAD, M-27	NO PILL, BIT LUBE II HAD BEEN USED DURING INTERVAL	EOW	15741
AKG285019	MARATHON	STEELHEAD, M-28	NONE, MUD CUT BY PRODUCING FORMATION	EOW	7152
AKG285019	MARATHON	STEELHEAD, M-29	NONE	EOW	
AKG285012	SWEPI	A, A23-01RD		ON PILL	
AKG288002	SWEPI	BURGER #1, OCS-Y 1413	NONE	EOW	6033
AKG288002	SWEPI	BURGER #1, OCS-Y 1413	NONE	EOW	
AKG288002	SWEPI	BURGER #1, OCS-Y 1413	NONE	EOW	
AKG285013	SWEPI	C, C11-23	NONE	EOW	12148
AKG285013	SWEPI	C, C12-23	NONE	EOW/NGM	
AKG285013	SWEPI	C, C13-23	NONE		
AKG285013	SWEPI	C, C13A-23	NONE	EOW	9693
AKG285013	SWEPI	C, C21-23	NONE	INTERIM FOR NGM	
AKG285013	SWEPI	C, C21-26			
AKG285013	SWEPI	C, C21A-26	BMI-1207 PILL, SAMPLE NOT TAKEN, NO RESULTS	ON PILL	40
AKG285013	SWEPI	C, C21A-23	NONE	EOW	
AKG285013	SWEPI	C, C22-23	NONE	EOW	5642
AKG285013	SWEPI	C, C24A-14		ON PILL	
AKG285013	SWEPI	C, C24A-23	NONE		
AKG285013	SWEPI	C, C41-26	NONE	INTERIM FOR NGM	

U.S. EPA, Region X Used Mud 96-Hr LC50s for Mysidopsis Bahia

PMTNO	OPNAME	WELLNAME	LC50	UNITS	TOXTYPE	TOXCITE	TOXDATE1	TOXDATE2	BASEMUD
AKG285013	SWEPI	C, C41-26	1000000	PPM SPP	USED/NGM	ABL 08/16/89 #890808-2	8/6/89		KCl2
AKG285013	SWEPI	C, C43-14	1000000	PPM SPP	USED/EOW	ABL 2/89 #890206-1			Cl2
AKG288006	SWEPI	CRACKERJACK #1, OCS-Y 1320	1000000	PPM SPP	USED/INTERIM	ABL 10/12/90 #901005-1	10/1/90	SAMPLE	2
AKG288006	SWEPI	CRACKERJACK #1, OCS-Y 1320	1000000	PPM SPP	USED/EOW	ABL 10/24/90 #901015-1	10/9/90	SAMPLE	2
AKG288006	SWEPI	CRACKERJACK #1, OCS-Y 1320	707000	PPM SPP	USED/EOW	ABL 9/6/91 #910826-1	8/22/91	SAMPLE	2
AKG288001	SWEPI	KLONDIKE #1, OCS-G-1482	190252	PPM SPP	USED/NGM	ABL 9/19/89 #890910-4	9/7/89	SAMPLE	NGM
AKG288003	SWEPI	POPCORN #1, OCS-Y 1275	1000000	PPM SPP	USED/INTERIM	ABL 10/30/89 #891020-1	10/17/89	SAMPLE	2
AKG288003	SWEPI	POPCORN #1, OCS-Y 1275	1000000	PPM SPP	USED/EOW	ABL 10/31/89 #891024-1	10/19/89	SAMPLE	2
AKG288003	SWEPI	POPCORN #1, OCS-Y 1275	1000000	PPM SPP	USED/INTERIM	ABL 8/8/90 #900801-5	7/28/90	SAMPLE	2
AKG288003	SWEPI	POPCORN #1, OCS-Y 1275	778000	PPM SPP	USED/EOW	ABL 10/1/90 #900925-1	9/19/90	SAMPLE	2
AKG284008	SWEPI	SANDPIPER #1	71900	PPM SPP	USED/PILL	MBL 5/7/86	3/23/86	SAMPLE	8
AKG284008	SWEPI	SANDPIPER #1	82200	PPM SPP	USED/PILL	MBL 5/7/86	3/27/86	SAMPLE	6
AKG284002	SWEPI	SEAL ISLAND #2 (?)	1600	WME	USED/PILL	BIOASSAY SUMMARY SHEET	5/1/84	SAMPLE	8
AKG284008	SWEPI	SANDPIPER #1	93400	PPM SPP	USED/PILL	MBL 5/7/86	3/22/86	SAMPLE	8
AKG284017	TENNECO	PHOENIX PROSPECT, #1	8464	PPM SPP WME	ESTIMATED	ALL + PILL	8/27/86	ESTIMATE	8
AKG284017	TENNECO	PHOENIX PROSPECT, #1	8720	PPM SPP WME	ESTIMATED	ALL ADDITIVES	6/27/86	ESTIMATE	6
AKG284017	TENNECO	PHOENIX PROSPECT, #1	10850	PPM SPP WME	ESTIMATED	ALL + PILL	8/27/86	ESTIMATE	6
AKG284017	TENNECO	PHOENIX PROSPECT, #1	12120	PPM SPP WME	ESTIMATED	ALL ADDITIVES	8/27/86	ESTIMATE	8
AKG285000	UNOCAL	BRUCE G.P. 18742-20 RD	108557	PPM SPP	USED/EOW	ANALYTIKEM Q10116	3/31/91	SAMPLE	Cl2
AKG285016	UNOCAL	GRAYLING, G-36DPN	546967	PPM SPP	USED/EOW	EHA 8/87 #870794	7/3/87	SAMPLE	Cl2
AKG285016	UNOCAL	GRAYLING, G-40 RD	565687	PPM SPP	USED/EOW	WA/CORE LAB #900657 2/90	3/15/90	SAMPLE	Cl2
AKG285017	UNOCAL	MONOPOD, A-8 RD	1000000	PPM SPP	USED/EOW	WEINTRITT 8/11/89	7/28/88	SAMPLE	Cl2
AKG285017	UNOCAL	MONOPOD, A-20 RD	805025	PPM SPP	USED/EOW	WA/CORE LAB #900860 5/90	4/21/90	SAMPLE	Cl2
AKG285017	UNOCAL	MONOPOD, A-28 RD	573326	PPM SPP	USED/EOW	WA/CORE LAB #900311 2/90	1/31/90	SAMPLE	NI

Shaded records did not adhere to all method or reporting requirements

U.S. EPA, Region X Used Mud 96-Hr LC50s for Mysidopsis Bahia

PMTNO	OPNAME	WELLNAME	PILLCITE	BIOREQ	BBLDISCH
AKG285013	SWEPI	C, C41-26	NONE	INTERIM FOR NGM	
AKG285013	SWEPI	C, C43-14	NONE		
AKG288006	SWEPI	CRACKERJACK #1, OCS-Y 1320	NONE, END OF INTERVAL-INTERMEDIATE WELL DEPTH	INTERIM	
AKG288006	SWEPI	CRACKERJACK #1, OCS-Y 1320	NONE	EOW	
AKG288006	SWEPI	CRACKERJACK #1, OCS-Y 1320	NONE	EOW	
AKG288001	SWEPI	KLONDIKE #1, OCS-G-1482	NONE	NGM	
AKG288003	SWEPI	POPCORN #1, OCS-Y 1275	NONE, END OF INTERVAL-INTERMEDIATE WELL DEPTH	INTERIM	
AKG288003	SWEPI	POPCORN #1, OCS-Y 1275	NONE, EOW	EOW	
AKG288003	SWEPI	POPCORN #1, OCS-Y 1275	NONE, END OF INTERVAL-INTERMEDIATE WELL DEPTH	INTERIM	14049
AKG288003	SWEPI	POPCORN #1, OCS-Y 1275	NONE	EOW	
AKG284006	SWEPI	SANDPIPER #1	HALLIBURTON/GMSO PILL, AFTER 90% REMOVAL	ON PILL	
AKG284006	SWEPI	SANDPIPER #1	HALLIBURTON PILL, AFTER 85% REMOVAL	ON PILL	
AKG284002	SWEPI	SEAL ISLAND #2 (?)	LUBE 106 @ 4 LB/BBL	ON PILL	
AKG284006	SWEPI	SANDPIPER #1	EZ SPOT/GMSO, AFTER 50% REMOVAL	ON PILL	
AKG284017	TENNECO	PHOENIX PROSPECT, #1	GMSO		
AKG284017	TENNECO	PHOENIX PROSPECT, #1	NO PILL IN THIS VALUE		
AKG284017	TENNECO	PHOENIX PROSPECT, #1	GMSO		
AKG284017	TENNECO	PHOENIX PROSPECT, #1	NO PILL IN THIS VALUE		
AKG285000	UNOCAL	BRUCE G.P. 18742-20 RD	NONE	EOW	3350
AKG285016	UNOCAL	GRAYLING, G-36DPN	NONE	ON PILL	
AKG285016	UNOCAL	GRAYLING, G-40 RD	NONE	EOW	
AKG285017	UNOCAL	MONOPOD, A-8 RD	NONE	EOW	
AKG285017	UNOCAL	MONOPOD, A-20 RD	NONE	EOW	3200
AKG285017	UNOCAL	MONOPOD, A-28 RD	NONE	EOW	

Shaded records did not adhere to all method or reporting requirements

APPENDIX D

SUMMARY OF LETHAL TOXICITY STUDIES OF DRILLING MUDS ON ALASKAN MARINE SPECIES

Summary of Lethal Toxicity Studies of Drilling Muds on Alaskan Marine Species. Test Animals are Adults Except Where Noted, and Some Test Animals may not be Alaskan Organisms

SPECIES	EXPOSURE DURATION	METHOD	LOWEST LC50 REPORTED IN mg/l (or PPM Vol:Vol)	DRILLING MUD PHASE AND TYPE[a]	REFERENCE
PHYTOPLANKTON					
Skeletonema costatum	96 hr	S,M	1,325[e,f]	W, lignosulfonate (IMCO RD-111+Spot)[b]	1
	96 hr	S,M	1,375[e,f]	W, lignosulfonate (IMCO lime)[b]	1
	96 hr	S,M	4,200[e,f]	W, lignosulfonate (IMCO RD-2000)[b]	1
	96 hr	S,M	4,650[e,f]	W, lignosulfonate (IMCO VC-10)[b]	1
	96 hr	S,M	4,700[e,f]	W, lignosulfonate (IMCO RD-111)[b]	1
	96 hr	S,M	5,700[e,f]	W, (IMCO nondispersed)[b]	1
	96 hr	S,M	3,700[e,f]	W, lightly-treated lignosulfonate	2,3
	96 hr	S,M	540[e,f]	W, seawater-gel	2,3
	96 hr	S,M	16,000[e,f]	W, freshwater lignosulfonate	2,3
	96 hr	S,U	430[e,f]	W, freshwater lignosulfonate	2,3
	96 hr	S,M	9,600[e,f]	Bentonite	3
	96 hr	S,M	1,650[e,f]	Barite	3
	96 hr	S,U	385[e,f]	Barite	3
INVERTEBRATES					
Echinoderms					
Echinarachnius parma (sperm)	15 min	S,U	(>10,000)[e]	LP, lignosulfonate	4
(eggs)	15 min	S,U	(<1,000)[e]	LP, lignosulfonate	4
Annelids					
Melaenis loveni	96 hr	S,U	(>600,000)	W,CMC/resinex/tannathin/gel	5,6
	96 hr	S,U	(>700,000)	W, CMC/resinex/tannathin	5,6
Nereis vexillosa	96 hr	S,U	(23,000)	W, weighted polymer	7
	96 hr	S,U	(37,000)	W, KCL-polymer	7
	96 hr	S,U	(41,000)	W, KCL-XP-polymer	7
	96 hr	S,U	(220,000)	W, seawater-polymer	7
	96 hr	S,U	(320,000)	W, weighted-gel-XC-polymer	7
	96 hr	S,U	(200,000)	W, gel-XC-polymers (2)	7
Nereis virens	96 hr	S,U	(>1,000,000)	W, high-density lignosulfonate	8
	96 hr	S,U	(>1,000,000)	SPP, high-density lignosulfonate	8
	96 hr	S,U	(>1,000,000)	W, medium-density lignosulfonate	8
	96 hr	S,U	(>1,000,000)	SPP, medium-density lignosulfonate	8
	96 hr	S,U	(>1,000,000)	W, light-density lignosulfonate	8
	96 hr	S,U	(>1,000,000)	SPP, light-density lignosulfonate	8
	96 hr	S,U	(>1,000,000)	SPP, spud mud	8
	96 hr	S,U	(>1,000,000)	SPP, seawater lignosulfonate	8
Molluscs					
Natica clausa	96 hr	S,U,NE	(>600,000)	W, CMC/resinex/tannathin/gel	5,6
Neptunia sp., and *Buccinum* sp.	96 hr	S,U,NE	(>700,000)	W, CMC/resinex/tannathin	5,6
Crassostrea gigas (spat)	96 hr	S,R,U	(11,900-19,796)	W, medium-density lignosulfonate	11

SPECIES	EXPOSURE DURATION	METHOD	LOWEST LC50 REPORTED IN mg/l (or PPM Vol:Vol)	DRILLING MUD PHASE AND TYPE[a]	REFERENCE
Mytilus edulis	96 hr	S,U	(>1,000,000)	SPP, high-density lignosulfonate	8
	96 hr	S,M	(>30,555[c] wt:vol)	W, high-density lignosulfonate	8
	96 hr	S,U	(>1,000,000)	SPP, medium-density lignosulfonate	8
	96 hr	S,M	(>22,827[c] wt:vol)	W, high-density lignosulfonate	8
	96 hr	S,U	(>16,536[c] wt:vol)	SPP, spud mud	8
	96 hr	S,U	(>24,085[c] wt:vol)	SPP, seawater lignosulfonate	8
Macoma balthica	96 hr	S,U	(>1,000,000)	SPP, high-density lignosulfante	8
	96 hr	S,U	(>1,000,000)	LP, high-density lignosulfante	8
	96 hr	S,U	(>1,000,000)	W, high-density lignosulfante	8
	96 hr	S,U	(>1,000,000)	SSP, light-density lignosulfante	8
	96 hr	S,U	(>1,000,000)	W, light-density lignosulfante	8
	96 hr	S,M	(>17,974[c] wt:vol)	W, light-density lignosulfante	8
Mya arenaria	96 hr	S,U	(10,000)	W, weighted polymer	7
	96 hr	S,U	(42,000)	W, KCL polymer	7
	96 hr	S,U	(56,000)	W, KCL-XC-polymer	7
	96 hr	S,U	(320,000)	W, seawater-polymer	7
	96 hr	S,U	(560,000)	W, weighted-gel-XC-polymer	7
	96 hr	S,U	(560,000)	W, gel-XC polymers (2)	7
Isopods					
Gnorimosphaeroma oregonensis	96 hr	S,M[d]	>2,000(>70,000)	W, high-density lignosulfonate	9
Saduria entomon	96 hr	S,U,NE	(314,000)	W, XC-polymer/unical	5,6
	96 hr	S,U,NE	(530,000)	W, CMC/resinex/tannathin/gel	5,6
Amphipods					
Anisogammarus confervicolus	96 hr	S,U	(10,000-50,000)	W, high-density lignosulfonate	9
	96 hr	S,U,NE	(150,000-200,000)	W high-density lignosulfonate	9
Orchestia traskiana	96 hr	S,U	(34,000)	W, weighted polymer	7
	96 hr	S,U	(14,000)	W, KCL-XC-polymer	7
	96 hr	S,U	(80,000-560,000)	W, gel-XC-polymers (2)	7
	96 hr	S,U	(230,000)	W, seawater-polymer	7
	96 hr	S,U	(420,000)	W, weighted-gel-XC-polymer	7
Onisimus sp., and/or *Boekosimus* sp.	96 hr	S,U,NE	(221,000)	W, XC-polymer/unical	5,6
Mysids					
Neomysis integer	96 hr	S,U	(100,000-120,500)	W, high-density lignosulfonate	9
	96 hr	S,M	1,600(10,000-50,000)	W, high-density lignosulfonate	9
	48 hr	S,U	(74,000)	W, high-density lignosulfonate	9
	48 hr	S,U	(>100,000)	SWP, high density lignosulfonate	9
Mysis sp.	96 hr	S,U	(<60,000)	W, CMC/gel/resinex	5,6
	96 hr	S,U	(215,000)	W, CMC/gel	5,6
	96 hr	S,U	(50,000-100,000)	W, XC-polymer	5,6
Shrimp					
Pandalus hypsinotus	96 hr	S,U	(150,000)	W, high-density lignosulfonate	9
	96 hr	S,M	14,000 (44,000)	W, high-density lignosulfonate	9
	96 hr	S,U	(32,000)	W, high-density lignosulfonate	9

SPECIES	EXPOSURE DURATION	METHOD	LOWEST LC50 REPORTED IN mg/l (or PPM Vol:Vol)	DRILLING MUD PHASE AND TYPE[a]	REFERENCE
Pandalus hypsinotus (larvae)	96 hr	S,U	(42,300-383,600)	LP, 5 Alaskan muds, not described	10
	96 hr	S,M	(>100,000)	Bentonite	9
	96 hr	S,M	(>100,000)	Barite	9
	96 hr	S,U	(16,300)	LP, lignosulfonate	10
	96 hr	S,U	(2,800)	W, lignosulfonate	10
Pandalus danae (larvae)	96 hr	S,U	(600)	W, lignosulfonate	10
	96 hr	S,U	(5,800)	LP, lignosulfonate	10
	96 hr	S,U	290	Ferrochrome lignosulfonate	10
Eualus sucklei (larvae)	96 hr	S,U	(11,900)	W, lignosulfonate	10
	96 hr	S,U	(9,100)	LP, lignosulfonate	10
Crabs					
Hemigrapsus nudus	96 hr	S,U	(62,000)	W, weighted polymer	7
	96 hr	S,U	(53,000)	W, KCL-polymer	7
	96 hr	S,U	(78,000)	W, KCL-XC-polymer	7
	96 hr	S,U	(530,000)	W, seawater-polymer	7
	96 hr	S,U	(560,000)	W, weighted-gel-XC-polymer	7
	96 hr	S,U	(560,000)	W, gel-XC-polymers (2)	7
Chionoecetes bairdi (larvae)	96 hr	S,U	(46,900)	LP, lignosulfonate	10
	96 hr	S,U	(27,400)	W, lignosulfonate	10
Cancer magister (larvae)	96 hr	S,U	(54,700)	LP, lignosulfonate	10
	96 hr	S,U	(7,300)	W, lignosulfontate	10
	96 hr	S,U	1,440	LP, ferrochrome lignosulfonate	10
Paralithodes camtschatica (larvae)	96 hr	S,U	(119,000)	LP, lignosulfonate	10
	96 hr	S,U	(49,000)	W, lignosulfonate	10
	96 hr	S,U	(80,400-824,000)	LP, 4 Alaskan muds, not described	10
Fishes					
Leptocottus armatus	48 hr	S,M	30,000(100,000-200,000)	W, high-density lignosulfonate	9
Myoxocephalus quadricornis	96 hr	S,U	(50,000-60,000)	W, CMC/gel/resinex	5,6
	96 hr	S,U	(>60,000)	W, XC-polymer	5,6
	96 hr	S,U	(>25,000)	SPP, XC-polymer	5,6
	96 hr	S,U	(>120,000)	W, CMC/gel	5,6
	96 hr	S,U	(350,000)	W, lignosulfonate	5,6
Oncorhynchus gorbuscha (fry)	96 hr	S,U	(29,000)	W, high-density lignosulfonate	9
	96 hr	S,M	1,100(3,000)	W, high-density lignosulfonate	9
	96 hr	S,U	(41,000)	W, KCL-polymer	7
O. keta	96 hr	S,U	(24,000)	W, KCL-polymer	7
O. kisutch	96 hr	S,U	(29,000)	W, KCL-polymer	7
	96 hr	S,U	(100,000-130,000)	W, seawater-polymer	7
	96 hr	S,U	(23,000)	W, KCL-XC-polymer	7
	96 hr	S,U	(15,000)	W, weighted polymer	7
	96 hr	S,U	(39,000)	W, gel-XC-polymer	7
	96 hr	S,U	(190,000)	W, weighted gel-XC-polymer	7
	96 hr	S,U	(30,000)	W, gel-XC-polymer	7
Salmo gairdneri	96 hr	S,U	(24,000)	W, KCL-polymer	7
Coregonus nasus	96 hr	S,U	(>200,000)	W, CMC/gel	5,6
	96 hr	S,U	(64,000)	W, XC-polymer	5,6
C. autumnalis	96 hr	S,U	(400,000)	W, lignosulfonate	6
Boreogadus saida	96 hr	S,U	(>250,000)	W, XC-polymer	5,6
Eleginus navaga	96 hr	S,U	(235,000)	W, CMC/gel	5,6

NOTES: a) Drilling mud descriptions, and trade names, by authors.
b) Laboratory formulated mud.
c) Calculated from author's data.
d) Some mixing by an aquarium pump.
e) An EC_{50} value.
f) Unknown whether concentration is Vol:Vol or mg/l.

ABBREVIATIONS:
M = Mixed or agitated (particulates resuspended).
R = Test solutions replaced at intervals.
S = Static.
U = Unmixed (particulates allowed to settle).
W = Whole mud.
LP = Liquid phase [= filtered SPP, EPA (1978); EPA/COE (1977)].
NE = Organisms not exposed to settled solids (behaviorally or by experimental design).
SPP = Suspended particulate phase [EPA (1978); EPA/COE (1977)].

REFERENCES:
1 = EG&G Marine Research Laboratory (1976)
2 = EG&G Bionomics (1976a)
3 = EG&G Bionomics (1976b)
4 = Crawford and Gates (1981)
5 = Tornberg et al. (1980)
6 = Northern Technical Services (1981)
7 = Environmental Protection Service (1975)
8 = Gerber et al. (1980)
9 = Houghton et al. (1980)
10 = Carls and Rice (1984)
11 = Neff et al. (1980)

Source: U.S. EPA (1984a), Appendix F